MARKET DAIRYING

MICHELS

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Market Dairying

BY

JOHN MICHELS, B.S.A., M.S. (Wisconsin)

Professor of Dairying and Animal Husbandry
in the State Agricultural College
of North Carolina

AUTHOR OF
"CREAMERY BUTTER-MAKING"
AND
"DAIRY FARMING"

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PREFACE.

Dairy instruction has hitherto been confined chiefly to the economical production of milk and the manufacture of butter and cheese. Yet those who have thoroughly studied the subject must admit that market dairying deserves fully as much attention as either the economical production of milk or the manufacture of butter or cheese.

The subject of market dairying presents two very important aspects: One is to educate dairymen to produce better and more wholesome milk; the other is to instruct them in all the economies relating to their business so as to insure maximum financial returns.

For a number of years the author has been brought face to face with the problems relating to market dairying. He has been actively engaged in the production and marketing of sanitary milk and cream, and in the manufacture and marketing of ice cream, cottage cheese, and skimmilk-buttermilk. The markets and dairy conditions of the country have been thoroughly investigated and new methods and plans have been developed, some of which have already been published in bulletin form or otherwise.

The production of this volume is, therefore, largely the result of the knowledge and experience thus gained, and the realization of the urgent and increasing needs along this line of dairying. An attempt has been made to so arrange the material that it might answer the needs of both the classroom and the dairyman who cannot attend a dairy school.

JOHN MICHELS.

April 1, 1909.

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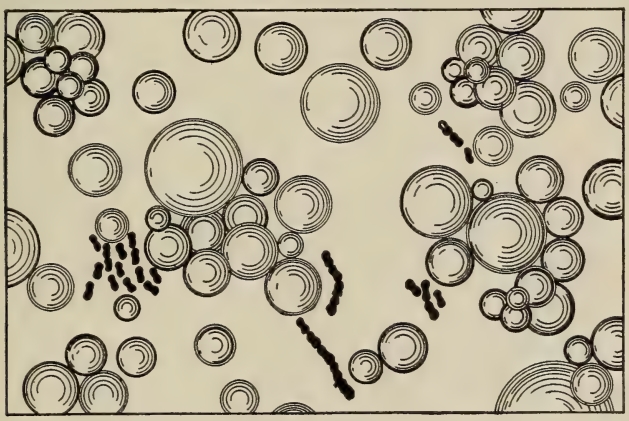
MARKET DAIRYING.

CHAPTER I.

CHEMICAL AND PHYSICAL PROPERTIES OF MILK.

Milk, in a broad sense, may be defined as the normal secretion of the mammary glands of animals that suckle their young. It is the only food found in Nature containing all the elements necessary to sustain life. Moreover it contains these elements in the proper proportions and in easily digestible and assimilable form.



Microscopic appearance of milk showing relative size of fat globules and bacteria.—Russell's Dairy Bacteriology.

Physical Properties. Milk is a whitish opaque fluid possessing a sweetish taste and a faint odor suggestive of cows' breath. It has an amphioteric reaction, that is,

it is both acid and alkaline. This double reaction is due largely to acid and alkaline salts and possibly to small quantities of organic acids.

Milk has an average normal specific gravity of 1.032, with extremes rarely exceeding 1.029 and 1.033. After standing a few moments it loses its homogenous character. Evidence of this we have in the "rising of the cream." This is due to the fact that milk is not a perfect solution but an *emulsion.* All of the fat, the larger portion of the casein, and part of the ash are in suspension.

In consistency milk is slightly more viscous than water, the viscosity increasing with the decrease in temperature. It is also exceedingly sensitive to odors, possessing great absorption properties. This teaches the necessity of placing milk in clean pure surroundings.

Chemical Composition. The composition of milk is very complex and variable, as will be seen from the following figures:

Average Composition of Normal Milk. A compilation of figures from various American Experiment Stations.

Water	87.1%
Butter fat	3.9%
Casein	2.9%
Albumen	.5%
Sugar	4.9%
Ash	.7%
Fibrin	Trace.
Galactase	Trace.
	100.0%

The great variations in the composition of milk are shown by the figures from Koenig, given below:

	Maximum.	*Minimum.*
Water	90.69	80.32
Fat	6.47	1.67
Casein	4.23	1.79
Albumen	1.44	.25
Sugar	6.03	2.11
Ash	1.21	.35

These figures represent quite accurately the maximum and minimum composition of milk except that the maximum for fat is too low. The author has known cows to yield milk testing 7.6% fat, and records show tests even higher than this.

BUTTER FAT.

This is the most valuable as well as the most variable constituent of milk. It constitutes about 83% of butter and is an indispensable constituent of the many kinds of whole milk cheese now found upon the market. It also measures the commercial value of milk and cream, and is used as an index of the value of milk for butter and cheese production.

Physical Properties. Butter fat is suspended in milk in the form of extremely small globules numbering about 100,000,000 per drop of milk. These globules vary considerably in size in any given sample, some being five times as large as others. The size of the globules is affected mostly by the period of lactation. As a rule the size decreases and the number increases with the advance of the period. In strippers' milk the globules are sometimes so small as to render an efficient separation of the cream and the churning of same impossible.

The size of the fat globules also varies with different breeds. In the Jersey breed the diameter of the globule

is one eight-thousandth of an inch, in the Holstein one twelve-thousandth, while the average for all breeds is about one ten-thousandth.

Night's milk usually has smaller globules than morning's. The size of the globules also decreases with the age of the cow.

The density or specific gravity of butter fat at 100° F. is .91 and is quite constant. Its melting point varies between wide limits, the average being 92° F.

Composition of Butter Fat. According to Richmond, butter fat has the following composition:

Butyrin	3.85	Soluble or volatile.
Caproin	3.60	
Caprylin	.55	
Caprin	1.90	Insoluble or non-volatile.
Laurin	7.40	
Myristin	20.20	
Palmitin	25.70	
Stearin	1.80	
Olein, etc.	35.00	

This shows butter fat to be composed of no less than nine distinct fats, which are formed by the union of glycerine with the corresponding fatty acids. Thus, butyrin is a compound of glycerine and butyric acid; palmitin, a compound of glycerine and palmitic acid, etc. The most important of these acids are palmitic, oleic, and butyric.

Palmitic acid is insoluble, melts at 144° F., and forms (with stearic acid) the basis of hard fats.

Oleic acid is insoluble, melts at 57° F., and forms the basis of soft fats.

Butyric acid is soluble and is a liquid which solidifies at —2° F. and melts again at 28° F.

Insoluble Fats. A study of these fats is essential in elucidating the variability of the churning temperature of cream. As a rule this is largely determined by the relative amounts of hard and soft fats present in butter fat. Other conditions the same, the harder the fat the higher the churning temperature. Scarcely any two milks contain exactly the same relative amounts of hard and soft fats, and it is for this reason that the churning temperature is such a variable one.

The relative amounts of hard and soft fats are influenced by:

1. Breeds.
2. Feeds.
3. Period of lactation.
4. Individuality of cows.

The butter fat of Jerseys is harder than that of Holsteins and, therefore, requires a relatively high churning temperature, the difference being about six degrees.

Feeds have an important influence upon the character of the butter fat. Cotton seed meal and bran, for example, materially increase the percentage of hard fats. Gluten feeds and linseed meal, on the other hand, produce a soft butter fat.

With the advance of the period of lactation the percentage of hard fat increases. This chemical change, together with the physical change which butter fat undergoes, makes churning difficult in the late period of lactation.

The individuality of the cow also to a great extent influences the character of the butter fat. It is inherent

in some cows to produce a soft butter fat, in others to produce a hard butter fat, even in cows of the same breed.

Soluble Fats. The soluble or volatile fats, of which butyrin is the most important, give milk and sweet cream butter their characteristic flavors. Butyrin is found only in butter fat and distinguishes this from all vegetable and other animal fats.

The percentage of soluble fats decreases with the period of lactation, also with the feeding of dry feeds and those rich in protein. Succulent feeds and those rich in carbohydrates, according to experiments made in Holland and elsewhere, increase the percentage of soluble fats. This may partly account for the superiority of the flavor of June butter.

It may be proper, also, to discuss under volatile or soluble fats those abnormal flavors that are imparted to milk, cream, and butter by weeds like garlic and wild onions, and by various feeds such as beet tops, rape, partially spoiled silage, etc. These flavors are undoubtedly due to abnormal volatile fats.

Cows should never be fed strong flavored feeds shortly before milking. When this is done the odors are sure to be transmitted to the milk and the products therefrom. When, however, feeds of this kind are fed shortly after milking no bad effects will be noticed at the next milking.

Albumenoids. These are nitrogenous compounds which give milk its high dietetic value. Casein, albumen, globulin, and nuclein form the albumenoids of milk, the casein and albumen being by far the most important.

Casein. This is a white colloidal substance, possessing neither taste nor smell. It is the most important tissue-forming constituent of milk and forms the basis of an almost endless variety of cheese.

The larger portion of the casein is suspended in milk in an extremely finely divided amorphus condition. It is intimately associated with the insoluble calcium phosphate of milk and possibly held in chemical combination with this. Its study presents many difficulties, which leaves its exact composition still undetermined.

Casein is easily precipitated by means of rennet extract and dilute acids, but the resulting precipitates are not identically the same. It is not coagulated by heat.

Albumen. In composition albumen very closely resembles casein, differing from this only in not containing sulphur. It is soluble and unaffected by rennet, which causes most of it to pass into the whey in the manufacture of cheese. It is coagulated at a temperature of 170° F. It is in their behavior toward heat and rennet that casein and albumen radically differ.

Milk Sugar. This sugar, commonly called lactose, has the same chemical composition as cane sugar, differing from it chiefly in possessing only a faint sweetish taste. It readily changes into lactic acid when acted upon by the lactic acid bacteria. This causes the ordinary phenomenon of milk souring. The maximum amount of acid in milk rarely exceeds .9%, the germs usually being checked or killed before this amount is formed. There is therefore always a large portion of the sugar left in sour milk. All of the milk sugar is in solution.

Ash. Most of the ash of milk exists in solution. It is composed of lime, magnesia, potash, soda, phosphoric acid, chlorine, and iron, the soluble lime being the most important constituent. It is upon this that the action of rennet extract is dependent. For when milk is heated to high temperatures the soluble lime is rendered insoluble and rennet will no longer curdle milk. It seems also that

the viscosity of milk and cream is largely due to soluble lime salts. Cream heated to high temperatures loses its viscosity to such an extent that it can not be made to "whip." Treatment with soluble lime restores its original viscosity. The ash is the least variable constituent of milk.

Colostrum Milk. This is the first milk drawn after parturition. It is characterized by its peculiar odor, yellow color, broken down cells, and high content of albumen which gives it its viscous, slimy appearance and causes it to coagulate on application of heat.

According to Eugling the average composition of colostrum milk is as follows:

Water	71.69%
Fat	3.37
Casein	4.83
Albumen	15.85
Sugar	2.48
Ash	1.78

The secretion of colostrum milk is of very short duration. Usually within four or five days after calving it assumes all the properties of normal milk. In some cases, however, it does not become normal till the sixth or even the tenth day, depending largely upon the condition of the animal.

A good criterion in the detection of colostrum milk is its peculiar color, odor, and slimy appearance. The disappearance of these characteristics determines its fitness for butter production.

Milk Secretion. Just how all of the different constituents of milk are secreted is not yet definitely understood. But it is known that the secretion takes

place in the udder of the cow, and principally during the process of milking. Further, the entire process of milk elaboration seems to be under the control of the nervous system of the cow. This accounts for the changes in flow and richness of milk whenever cows are subjected to abnormal treatment. It is well known that a change of milkers, the use of rough language, or the abuse of cows with dogs and milk stools, seriously affects the production of milk and butter fat. It is therefore of the greatest practical importance to milk producers to treat cows as gently as possible, especially during the process of milking.

How Secreted. The source from which the milk constituents are elaborated is the blood. It must not be supposed, however, that all the different constituents already exist in the blood in the form in which we find them in milk, for the blood is practically free from fat, casein, and milk sugar. These substances must then be formed in the cells of the udder from material supplied them by the blood. Thus there are in the udder cells that have the power of secreting fat in a manner similar to that by which the gastric juice is secreted in the stomach. Similarly, the formation of lactose is the result of the action of another set of cells whose function is to produce lactose. It is believed that the casein is formed from the albumen through the activity of certain other cells. The water, albumen, and soluble ash probably pass directly from the blood into the milk ducts by the process known as osmosis.

Variations in the Quality of Milk. Milk from different sources may vary considerably in composition, particularly in the percentage of butter fat. Even the

milk from the same cow may vary a great deal in composition. The causes of these variations may be assigned to two sets of conditions: I.—Those natural to the cow. II.—Those of an artificial nature.

I. QUALITY OF MILK AS AFFECTED BY NATURAL CONDITIONS.

1. The composition of the milk of all cows undergoes a change with the advance of the period of lactation. During the first five months the composition remains practically the same. After this, however, the milk becomes gradually richer until the cow "dries up." The following figures from Van Slyke illustrate this change:

Month of lactation.	*Per cent of fat in milk.*
1	4.54
2	4.33
3	4.28
4	4.39
5	4.38
6	4.53
7	4.56
8	4.66
9	4.79
10	5.00

It will be noticed from these figures that the milk actually decreases somewhat in richness during the first three months of the period. But just before the cow dries up, it may test as high as 8%.

2. The quality of milk also differs with different breeds. Yet breed differences are less marked than those of the individual cows of any particular breed.

Some breeds produce rich milk, others relatively poor

milk. The following data obtained at the New Jersey Experiment Station illustrates these differences:

Breed.	Total Solids.	Fat.	Milk Sugar.	Proteids.	Ash.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Ayshire.....	12.70	3.68	4.84	3.48	.69
Guernsey	14.48	5.02	4.80	3.92	.75
Holstein	12.12	3.51	4.69	3.28	.64
Jersey.....	14.34	4.78	4.85	3.96	.75

3. Extremes in the composition of milk are usually to be ascribed to the individuality or "make up" of the cow. It is inherent in some cows to produce rich milk, in others to produce poor milk. In other words, Nature has made every cow to produce milk of a given richness, which can not be perceptibly changed except by careful selection and breeding for a number of generations.

II. QUALITY OF MILK AS AFFECTED BY ARTIFICIAL CONDITIONS.

1. When cows are only partially milked they yield poorer milk than when milked clean. This is largely explained by the fact that the first drawn milk is always poorer in fat than that drawn last. Fore milk may test as low as .8%, while the strippings sometimes test as high as 14%.

2. Fast milking increases both the quality and the quantity of the milk. It is for this reason that fast milkers are so much preferred to slow ones.

3. The richness of milk is also influenced by the length of time that elapses between the milkings. In general, the shorter the time between the milkings the richer the milk. This, no doubt, in a large measure accounts for the differences we often find in the richness of morning's and night's milk. Sometimes the morning's milk is the richer, at other times the evening's, depending largely upon the time of day the cows are milked. Milk can not, however, be permanently enriched by milking three times instead of twice a day.

4. Unusual excitement of any kind reduces the quality of milk. The person who abuses cows by dogs, milk stools, or boisterousness, pays dearly for it in a reduction of both the quality and the quantity of milk produced.

5. Starvation also seriously affects both the quality and the quantity of milk. It has been repeatedly shown, in this country and in Europe, that under-feeding to any great extent results in the production of milk poor in fat.

6. Sudden changes of feed may slightly affect the richness of milk, but only temporarily.

So long as cows are fed a full ration, it is not possible to change the richness of milk permanently, no matter what the character of feed composing the ration.

7. Irregularities of feeding and milking, exposure to heat, cold, rain, and flies, tend to reduce both the quantity and the quality of milk produced.

CHAPTER II.

BACTERIA IN MILK.

The term bacteria is applied to the smallest of living plants, which can be seen only under the highest powers of the miscroscope. Each bacterium is made up of a single cell. These plants are so small that it would require 30,000 of them laid side by side to measure an inch. Their presence is almost universal, being found in the air, water, and soil; in cold, hot, and temperate climates; and in living and dead as well as inorganic matter.

Bacteria grow with marvelous rapidity. A single bacterium is capable of reproducing itself a million times in twenty-four hours. They reproduce either by a simple division of the mother cell, thus producing two new cells, or by spore formation in which case the contents of the mother cell are formed into a round mass called a spore. These spores have the power of withstanding unfavorable conditions to a remarkable extent, some being able to endure a temperature of 212° F. for several hours.

Most bacteria require for best growth a moist, warm, and nutritious medium such as is furnished by milk, in which an exceedingly varied and active life is possible.

In nature and in many of the arts and industries, bacteria are of the greatest utility, if not indispensable. They play a most important part in the disintegration of vegetable and animal matter, resolving compounds into their elemental constituents in which form they can again

be built up and used as plant food. In the art of butter and cheese making bacteria are indispensable. The tobacco, tanning, and a host of other industries cannot flourish without them.

Lactic Acid Bacteria. In milk and cream intended for direct consumption, bacteria of any kind are enemies to dairymen. The class of bacteria that is feared more than any other, perhaps, is that which causes milk to sour. The organisms belonging to this class are known as lactic acid bacteria. They are non-spore bearing and grow best at a temperature of from 90° to 98° F. At 40° F. their growth ceases; exposed to a temperature of 140° for 15 minutes they are killed.

The souring of milk and cream is due to the action of the lactic acid bacteria upon the milk sugar changing it into lactic acid. Acid is therefore always produced at the expense of milk sugar. But the sugar is never all converted into acid because the production of acid is limited. When the acidity reaches about .9% the lactic acid bacteria are either checked or killed and the production of acid ceases. Owing to the universal presence of these bacteria it is almost impossible to secure milk free from them.

Under cleanly conditions the lactic acid type of bacteria always predominates in milk. When, however, milk is drawn under uncleanly conditions the lactic organisms may be outnumbered by other species of bacteria which give rise to the numerous taints often met with in milk.

While the acid bacteria are objectionable in milk intended for direct consumption, in cream made into butter they are indispensable. The highly desirable aroma in butter is the result of the growth of these organisms in the process of cream ripening. There are a number of

different species of bacteria that have the power of producing lactic acid. Milk containing only lactic acid bacteria is spoken of as a "pure culture" or "starter." Such cultures are now a commercial product and should be used wherever fancy butter and cheese and sour milk products are desired. The method of using these pure cultures or starters is discussed in the chapter on cottage cheese making, page 90.

Bacteria that Produce Taints and Bad Odors. While the lactic are the commonest bacteria of milk, there are always present many other types, some of which produce serious taints and bad odors. Bacteria of this kind are usually associated with filth, and dairies that become strongly infected with them show lack of cleanliness in the care and handling of the milk.

The commonest bad flavors produced by this class of bacteria may be designated as rancid, bitter, strong, gassy, oily, fishy, and putrefactive. In market milk these filth bacteria are objectionable not only because of the bad flavors they produce, but also because they are recognized as a common cause of infantile troubles, such as diarrhœa. The high mortality among bottle-fed babies has been shown to be largely due to drinking milk that has been produced under unsanitary conditions.

Disease Producing Bacteria. Milk frequently becomes infected with this class of bacteria through diseased cows, infected water, infected milk vessels, and diseased attendants.

One of the commonest of the disease producing bacteria is the bacillus tuberculosis. This germ usually finds entrance into the milk in two ways: It may come from the cow directly through her milk, or it may gain access to the milk through the litter in the barn. No milk should

be offered for sale except that produced from cows that have been shown to be free from tuberculosis by the tuberculin test.

A common means of infecting milk is through the water used in the dairy. Many typhoid fever epidemics have been positively traced to milk infected with typhoid organisms through the water supply. The purity of the water used in a dairy should be absolutely above suspicion.

Another means of spreading disease through milk is the milk bottle. Every dairyman will, at some time, have customers in whose families there is sickness, and bottles passing unsterilized from such homes to healthy ones, are often the means of communicating the disease to the latter. Many instances of this kind are on record. The absolute necessity of *sterilizing* the milk bottles to prevent the spread of contagious diseases is too evident to require further discussion.

Milkers and attendants who come in contact with persons suffering from contagious diseases, or who may themselves be afflicted with disease, should be rigidly excluded from the dairy. Over five hundred epidemics of various diseases, such as scarlet fever, diphtheria, typhoid fever, etc., have been directly traced to infected milk.

With the large number of bacteria ordinarily found in milk and with the great variety of pathogenic organisms that are often disseminated by means of it, it behooves us to know under what conditions milk should be produced and handled to reduce bacterial contamination to a minimum. These conditions will be discussed in the following chapter.

CHAPTER III.

SANITARY MILK PRODUCTION.

Sanitary Milk Defined. Sanitary milk is milk from healthy cows, produced and handled under conditions in which contamination from filth, bad odors, and bacteria, is reduced to a minimum.

Importance of Sanitary Milk. The production of clean milk is one of the most important subjects that confronts the American dairyman at the present time. Further improvement in the quality of butter and cheese must largely be sought in the use of cleaner milk. With the better appreciation by the public of the great nutritive value of milk, there opens an unlimited market for it for consumption in the raw form. Already we find that milk produced under the best sanitary conditions sells for practically double that obtained under ordinary, more or less, slip-shod conditions. So great is the clamor for cleaner milk that any extra efforts expended in producing it are certain to be richly compensated.

The Necessary Conditions for the production of sanitary milk are as follows: (1) Healthy cows; (2) sanitary barn; (3) clean barn yard; (4) clean cows; (5) clean milkers; (6) clean milk vessels; (7) clean, wholesome feed; (8) pure water; (9) clean strainers; (10) dust-free stable air; (11) clean bedding; (12) milking with dry hands; (13) thorough cooling of milk after milking; (14) sanitary milk room.

Healthy Cows. The health of the cow is of prime importance in the production of sanitary milk. All milk

from cows affected with contagious diseases should be rigidly excluded from the dairy. Aside from the general unfitness of such milk there is danger of the disease producing organisms getting into the milk. It has been found, for example, that cows whose udders are affected with tuberculosis, yield milk containing these organisms. The prevalence of this disease among cows at present makes it imperative to determine definitely whether or not cows are affected with the disease, by the application of the tuberculin test.

Any feverish condition of the cow tends to impart a feverish odor to the milk, which should therefore not be used. Especially important is it that milk from diseased udders, no matter what the character of the disease, be discarded.

Sanitary Barn. Light, ventilation, and ease of cleaning are essential to a sanitary dairy barn. The disinfectant action of an abundance of sunlight, secured by providing a large number of windows, is of the highest importance.

Of equal importance is a clean, pure atmosphere, secured by a continuous ventilating system. The fact that odors of any description are absorbed by milk with great avidity, sufficiently emphasises the great need of pure air.

To permit of easy cleaning, the barn floors and gutters should be built of concrete. They should be scrubbed daily, and care should be taken to keep the walls and ceiling free from dust and cobwebs. The feed boxes must also be cleaned after each feed.

The stalls should be of the simplest construction, to afford as little chance for lodgement of dust as possible. Furthermore, they should so fit the cows as to cause the latter to stand with their hind feet on the edge of the gut-

ter, a matter of the highest importance in keeping cows clean.

The walls and ceiling should be as smooth as possible. Moreover, they should be frequently disinfected by means of a coat of whitewash. The latter gives the barn a striking sanitary appearance.

Clean Barn Yard. A clean, well drained barn yard is an essential factor in the production of sanitary milk. Where cows are obliged to wade in mire and filth, it is easy to foretell what the quality of the milk will be. To secure a good barn yard it must be covered with gravel or cinders, and should slope away from the barn. If the manure is not taken directly from the stable to the fields, it should be placed where the cows cannot have access to it.

Clean Cows. Where the barn and barn-yard are sanitary, cows may be expected to be reasonably clean. Yet cows that are apparently clean, may still be the means of infecting milk to no small degree. When we consider that every dust particle and every hair that drops into the milk may add hundreds, thousands, or even millions of bacteria to it, we realize the importance of taking every precaution to guard against contamination from this source.

To keep cows as free as possible from loose hair and dust particles they should be carded and brushed regularly once a day. This should be done after milking to avoid dust. Five to ten minutes before the cow is milked her udder and flanks should be gently washed with clean, tepid water, by using a clean sponge or cloth. This will allow sufficient time for any adhering drops of water to drip off, at the same time it will keep the udder and flanks sufficiently moist to prevent dislodgment of dust particles

and hairs at milking time. This practically means that the milker must always have one or two cows washed ahead. He should be careful to wash his hands in clean water after each washing.

Under ordinary conditions the cow is the greatest source of milk contamination. The rubbing of the milker against her and the shaking of the udder will dislodge numerous dust particles and hairs unless the foregoing instructions are rigidly followed.

Attention should also be given to the cow's switch, which should be kept scrupulously clean. The usual switching during milking is no small matter in the contamination of milk when the switch is not clean.

Clean Milkers. Clothes which have been worn in the fields are not suitable for milking purposes. Every milker should be provided with a clean, white milking suit, consisting of cap, jacket and trousers. Such clothes can be bought ready made for one dollar; and, if frequently laundered, will materially aid in securing clean milk.

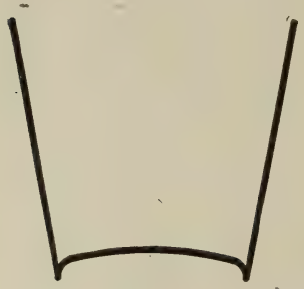


Fig. 1. Unflushed seam.

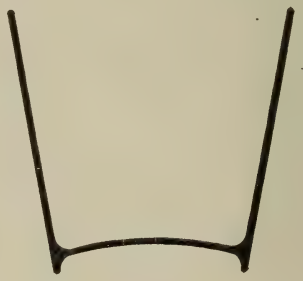


Fig. 2. Flushed seam.

Milkers should also wash and dry their hands before milking, and, above all, should keep them dry during milking.

Clean Vessels. All utensils used in the handling of

milk should be made of good tin, with as few seams as possible. Wherever seams occur, they should be flushed with solder. Unflushed seams are difficult to clean, and, as a rule, afford good breeding places for bacteria. Fig. 1 illustrates the character of the unflushed seam; Fig. 2 shows a flushed seam, which fully illustrates its value.

Fig. 3 illustrates a modern sanitary milk pail. The value of a partially closed pail is evident from the reduced opening, which serves to keep out many of the micro-organisms that otherwise drop into the pail during

Fig. 3. Sanitary Milk Pail.

milking. While such a pail is somewhat more difficult to clean than the ordinary open pail, it is believed that the reduced contamination during milking far outweighs this disadvantage.

All utensils used in the handling of milk should be as nearly sterile as possible. A very desirable method of cleaning them is as follows:

First, rinse with warm or cold water. Second, scrub

with moderately hot water containing some sal soda. The washing should be done with brushes rather than cloth because the bristles enter into any crevices present which the cloth cannot possibly reach. Furthermore, it is very difficult to keep the cloth clean. Third, scald thoroughly with steam or hot water, after rinsing out the water in which the sal soda was used. After scalding, the utensils should be inverted on the shelves without wiping and allowed to remain in this place until ready to use. This will leave the vessels in a practically sterile condition. Fourth, if it is possible to turn the inside of the vessels to the sun, in a place where there is no dust, then it is desirable to expose the utensils during the day to the strong germicidal action of the direct sun's rays.

Clean, Wholesome Feed. Highly fermented and aromated feeds, like sour brewers grains and leeks should be rigidly withheld from dairy cows when anything like good flavored milk is sought. So readily does milk absorb the odors of feeds through the system of the animal, that even good corn silage, when fed just previous to milking, will leave its odor in the milk. When fed after milking, however, no objection whatever can be raised against corn silage because not a trace of its odors is then found in the milk. Aromatic feeds of any kind should always be fed after milking.

Pure Water. Since feeds are known to transmit their odors to the milk through the cow, it is reasonable to expect water to do the same. Cows should, therefore, never be permitted to drink anything but pure, clean-flavored water. The need of pure water is further evident from the fact that it enters so largely into the composition of milk.

The water of ponds and stagnant streams is especially dangerous. Not only is such water injurious to the health of cows, but in wading into it, they become contaminated with numerous undesirable bacteria, some of which may later find their way into the milk.

Strainers and Straining. Milk should be drawn so clean as to make it almost unnecessary to strain it. This operation is frequently done under the delusion that so long as it removes all visible dirt the milk has been entirely purified. The real harm, however, that comes from hairs and dust particles dropping into the milk is not so much in the hairs and dust particles themselves as in the millions of bacteria which they carry with them. These bacteria are so small that no method of straining will remove them. Straining can not even remove all of the dirt, because some of it will go in solution.

A good strainer consists of two thicknesses of cheese cloth with a layer of absorbent cotton between. The strainer is to be placed on the can or vat into which the milk is to be strained and not on the milk pail. While a strainer like the above placed upon the milk pail, reduces the bacterial content slightly in the hands of careful milkers, it is believed that the slight advantage gained would be more than off-set by greater carelessness in milking; especially might this be true with ignorant milkers who are apt to think that the strainer will make up for any carelessness on their part. A cheese cloth strainer on the milk pail is worse than useless with any kind of milker.

New sterilized cotton must be used at each milking and the cloths must be thoroughly washed and sterilized. Like the cotton, it is best to use the cloth but once.

Dust-Free Air. Great precaution should be taken not

to create any dust in the stable about milking time, for this is certain to find its way into the milk. Cows should, therefore, never be bedded or receive any dusty feed just before or during milking.

Dry roughage, such as hay and corn fodder, always contains a considerable amount of dust, and when fed before or during milking may so charge the air with dust as to make clean milk an impossibility.

Moistening the floor and walls with clean water previous to milking materially minimizes the danger of getting dust into the milk. A mistake not infrequently made even in the better class of dairies is to card and brush the cows just before milking. While this results in cleaner cows, the advantage thus gained is far more than offset by the dirtier air, which, as will be shown later, materially increases the germ content of the milk. The carding and brushing should be done at least thirty minutes before the milking commences.

Clean Bedding. Clean shavings and clean cut straw should preferably be used for bedding. Cows stepping and lying on dirty bedding will soil themselves and create a dusty barn air.

Milking With Dry Hands. A prolific source of milk contamination is the milking with wet hands. Where the milker wets his hands with milk, some of it is bound to drip into the pail, carrying with it thousands or millions of bacteria, depending upon the degree of cleanliness of the milker's hands and the cow's udder. There is no excuse for the filthy practice of wet milking, since it is just as easy to milk with dry hands.

Fore-Milk. Where the purest milk is sought, it is desirable to reject the first stream or two from each teat, as this contains many thousands of bacteria. The reason

for this rich development of germs is found in the favorable conditions provided by the milk in the milk-ducts of the teats, to which the bacteria find ready access.

Flies. Flies not only constitute a prolific but also a dangerous source of milk contamination. These pests visit places of the worst description and their presence in a dairy suggests a disregard for cleanliness. Of 414 flies examined by the Bacteriologist of the Connecticut Station, the average number of bacteria carried per fly was *one and a quarter millions.* Flies should be rigidly excluded from all places where they are apt to come in contact with the milk.

Experimental Data. To show to what extent the bacterial content of milk may be reduced by adopting the precautions suggested in the foregoing pages, a few experimental data are herewith presented.

In Bulletin No. 42 of the Storrs (Conn.) Experiment Station, Stocking reports the following:

1. When the cows were milked before feeding the number of bacteria per c. c. was 1,233; when milked immediately after feeding, the number of bacteria was 3,656, or *three* times as many.

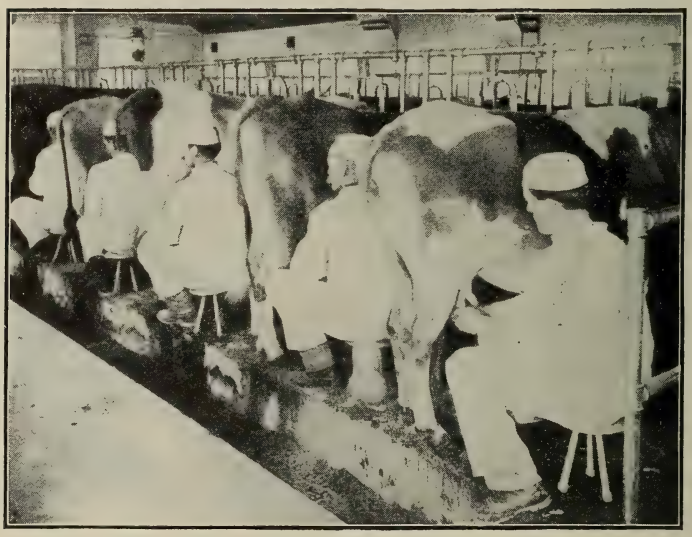
2. When the udder and flanks of the cows were wiped with a damp cloth, the number of bacteria per c. c. was 716; when not wiped the number was 7,058, or *ten* times as great.

3. When the cows were not brushed just before milking the number of bacteria per c. c. was 1,207; when brushed just before milking, the number was 2,286, or nearly *twice* as great.

4. When students who had studied the production of clean milk did the milking, the number of bacteria per c. c. was 914; when the milking was done by regular

unskilled milkers the number of bacteria was 2,846, or *three* times as great.

Wiping or washing udders before milking not only very materially reduces the bacterial content of the milk, but also lessens the amount of dirt to a very great extent. Frazer has shown that "the average weight of dirt which falls from muddy udders during milking is *ninety* times as great as that which falls from the same udder after washing, and when the udder is slightly soiled it is eighteen times as great."



Clean Milking. (From Da. Div., U. S. Dept. of A.)

CHAPTER IV.

COOLING AND AERATION OF MILK AND CREAM.

Importance of Low Temperature. Milk always contains bacteria no matter how cleanly the conditions under which it is drawn. At ordinary temperatures these bacteria increase with marvelous rapidity; at low temperatures their growth practically ceases. The effect of temperature on bacterial development is graphically shown in Fig. 4.

Fig. 4.—Relation of temperature to bacterial growth.

a represents a single bacterium; *b*, its progeny in twenty-four hours in milk kept at 50° F.; *c*, its progeny in twenty-four hours in milk kept at 70° F. (Bul. 26, Storrs, Conn.)

At a temperature of 50° F. the bacteria multiplied five times; at 70° F. they multiplied seven hundred and fifty times.

Roughly speaking, at 98° F. bacteria multiply one hun-

dred times faster than at 70° F. At 32° F. bacterial development practically ceases.

Milk or cream may be kept sweet a long time at 40° to 45° F. because the lactic acid bacteria practically stop growing at these temperatures. But there are other classes of bacteria that can grow at these temperatures, as evidenced by the production of undesirable flavors. Such flavors usually become noticeable after thirty-six hours. Where milk and cream are to be kept in the best possible condition, it is necessary to reduce the temperature to within a few degrees of freezing.

Lack of thorough cooling necessitates two deliveries of milk per day, and, what is still worse, requires many dairymen to milk their cows shortly after midnight and shortly after midday, a drudgery which casts a damper upon the whole milk business. Lack of cooling also means financial loss through souring of milk and leads to many dissatisfied customers.

Prompt Cooling. Milk should be cooled as quickly as possible after it is drawn. Indeed, the milk should be taken directly from the cow to the cooling room and promptly cooled. To do this conveniently it is necessary to have the cooling room located as near the barn as is consistent with freedom from barn odors.

Too often the milk is allowed to remain in the barn until all the cows have been milked, and this may require from two to three hours, depending upon the number of cows milked by each milker. A few hours delay in cooling reduces the keeping quality of milk to a far greater extent than is commonly supposed.

Importance of Aeration. Milk not only contains bacteria immediately after it is drawn, but it also contains gases, chief among which, perhaps, is car-

bonic acid gas. These gases should be removed as quickly as possible after milking by exposing the milk in thin sheets to the atmosphere. Fortunately the construction of modern coolers is such as to make it possible to do the cooling and aerating in one operation.

Formerly it was customary for dairymen to aerate their milk before cooling. Such practice is known to give somewhat better aeration than is possible where the cooling and aerating are performed in the same operation; yet the difference is so slight that consumers cannot detect it. The practice of aerating first and cooling afterward is therefore being abandoned.

Coolers. All modern coolers permit cooling with ice water. Without this a sufficiently low temperature cannot be obtained to stop practically all bacterial growth. To meet the requirements of dairies of different sizes, several styles of coolers are herewith described and illustrated.

Corrugated Cooler. This style of cooler is shown in Fig. 5, which also shows a desirable method of fastening it. It is especially adapted to dairies having from fifteen to thirty cows. The cooler consists of two parts: An upper section which is used to cool milk and cream with uniced water, and a lower section through which ice water is circulated.

A storage tank for well water may be placed above the ceiling. From this the water is admitted to the upper section through the valve which is used to regulate the flow. As shown by the arrows the water enters the section at the bottom and discharges at the top. The waste water may be conducted to the feed water tank of the boiler, to a watering trough, or other places where it may be useful.

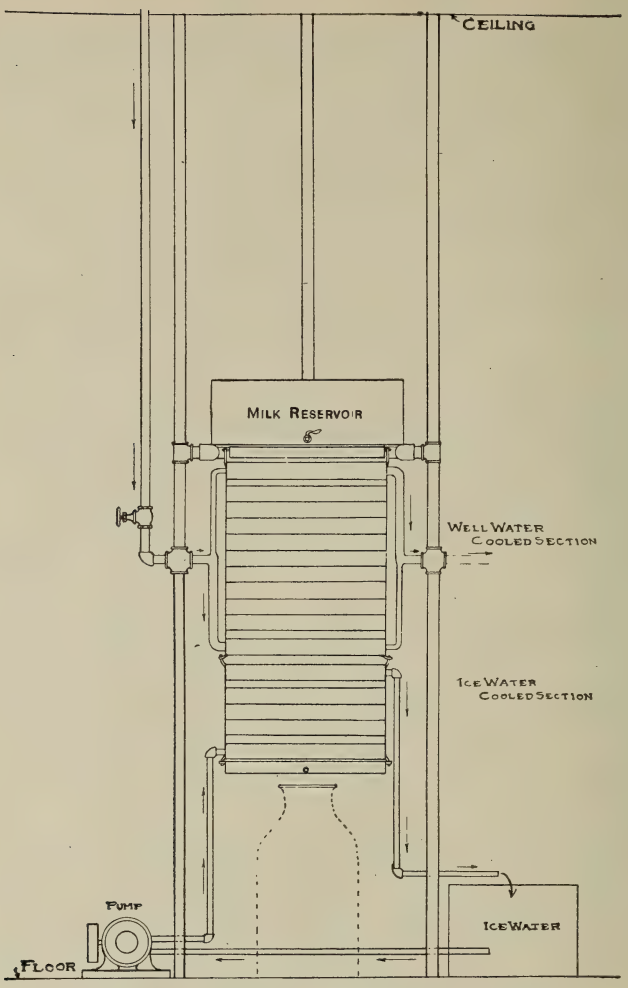


Fig. 5.—Showing Corrugated Cooler and Method of Support.

By means of the pump at the left, the ice water is forced back into the small tank at the right, which contains finely crushed ice.

As might be expected, by forcing the ice water from the cooler back into the ice water storage, a considerable saving is effected, not only of ice and water, but of time as well. Proof of these advantages is brought out by the results recorded in the following table, which shows the work of the cooler with and without the ice water pump. When no pump was used, ordinary well water was sprayed over finely crushed ice in the can shown at the right, and the discharge was allowed to run into the drain.

TABLE SHOWING WORK OF COOLER WITH AND WITHOUT THE PUMP.

Number of Experiment.		Amount Ice Used—Pounds.	Time in Cooling—Minutes.	Temperature of Milk Before Cooling—Degrees F.	Temperature of Well Water—Degrees F.
No. 1	With pump	37	45	85	73
	Without pump	89	92	88	73
No. 2	With pump	35	40	85	66
	Without pump	94	82	84	66
No. 3	With pump	32	35	82	64
	Without pump	85	93	85	64
No. 4	With pump	38	45	88	72
	Without pump	95	85	85	72
No. 5	With pump	34	43	85	70
	Without pump	83	88	88	70
Average	With pump	35	41	85	69
	Without pump	89	88	86	69

All the milk was cooled to 45° F., and the amount of milk cooled in each experiment was forty-four gallons, one-half of which was cooled with a pump and the other half without.

The above figures show that less than half the amount of ice and less than half as much time were required in cooling with the pump than when no pump was used.

Where no ice is intended to be used, coolers may be purchased without the ice water section.

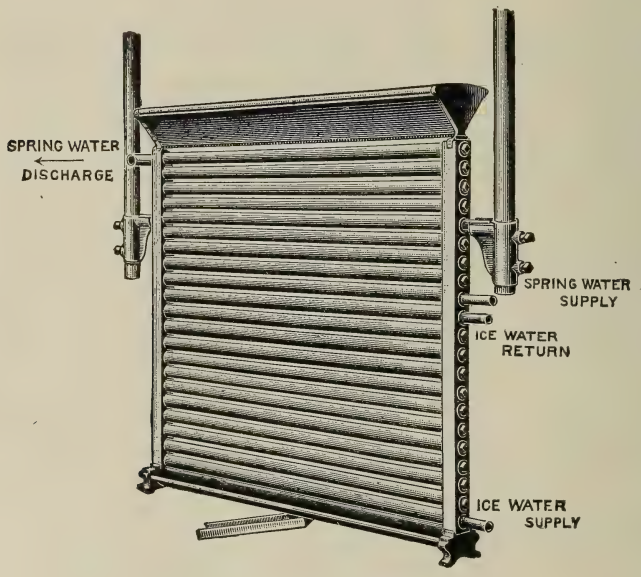


Fig. 6.—Tubular Cooler.

The cooler is fastened by means of two-inch galvanized iron gas pipes, the lower ends of which are embedded in the concrete floor while the upper ends are at-

tached to the ceiling (Fig. 5). The milk reservoir is also supported by galvanized iron gas pipes, in the manner shown in the illustration.

The water pump should be fastened to the concrete floor in a manner similar to that in which the cream separator is fastened (see page 57).

Tubular Cooler. Fig. 6 illustrates this type of cooler, which is recommended for dairymen having thirty or more cows. This cooler is very substantial, and, as a rule, has greater width in proportion to length than the corrugated style, which leaves the top of the cooler a more convenient distance from the floor. It may be fastened and operated in the same manner as the corrugated cooler shown in Fig. 5.

Cone-Shaped Cooler. For dairies having fewer than fifteen cows a cheap cooler like that shown in Fig. 7 may be used to advantage. The water enters the bottom of the cooler and discharges at the top, while the milk flows in a thin sheet over the outside. Ice may be placed inside the cooler, if desired. The can at the top is the milk receiver, which has small openings at the bottom near the outside, through which the milk discharges in fine streams, directly upon the cone below.

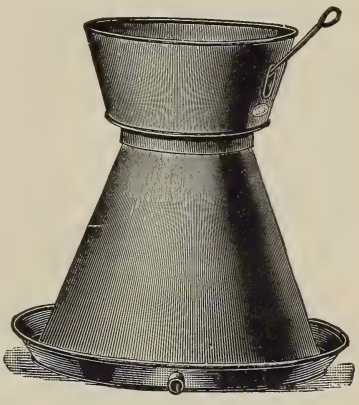


Fig. 7.—Cone Shaped Cooler.

Cooling With Brine. This is the cleanest, most con-

venient and efficient, and, in many cases, the cheapest method of cooling milk and cream. The brine may be reduced to any temperature desired with a mechanical refrigerating machine. It is forced through the cooler with a pump, in the same manner as ordinary ice water. With the latter it is difficult to cool milk and cream below 40° F., while with the brine the temperature is easily reduced to 34° F., at which milk and cream remain practically without change. Such a low temperature is especially desirable in shipping milk and cream. When cream leaves the dairy at a temperature near freezing, it may be shipped in an ordinary can wrapped with a felt jacket a distance of 500 miles or more in warm weather without undergoing a noticeable change in either flavor or acidity.

Precautions in Cooling. While cooling milk or cream, the room should be kept damp, especially the floor. This will keep down any dust that may be in the room and thus keep it from getting into the milk. Draughts should be avoided during cooling for the same reason. In this connection it is well to remember that the real harm is not so much in the dust particles themselves as in the many bacteria which usually adhere to them.

Where coolers are left exposed to the air of the room after they have been cleaned and sterilized, they should be rinsed off with boiling water just before using.

It is important also to use a reliable thermometer. Ordinary cheap thermometers often read two to six degrees too high or too low. A standard thermometer should be on hand, by which the cheaper ones may be standardized.

Never Use Ice in Milk or Cream. Adding ice directly to milk and cream is a pernicious, though not un-

common, practice. The best of natural ice contains dirt and bacteria. Even ice made by mechanical means from distilled water often contains considerable quantities of impurities. Ice also is an adulterant just as much as water. In case of cream cooled with ice the body is unsatisfactory, even if the cream contains the required amount of fat.

CHAPTER V.

THE BABCOCK TEST.

This is a cheap and simple device for determining the percentage of fat in milk, cream, skim-milk, buttermilk, whey, and cheese. It was invented in 1890 by Dr. S. M. Babcock, of the Wisconsin Agricultural Experiment Station, and ranks among the leading agricultural inventions of modern times. The chief uses of the Babcock test may be mentioned as follows:

1. It has made possible the payment for milk according to its quality.
2. It has enabled butter and cheese makers to detect undue losses in the process of manufacture.
3. It has made possible the grading up of dairy herds by locating the poor cows.
4. It has, in a large measure, done away with the practice of watering and skimming milk.

Principle of the Babcock Test. The separation of the butter fat from milk with the Babcock test is made possible:

1. By the difference between the specific gravity of butter fat and milk serum.
2. By the centrifugal force generated in the tester.
3. By burning the solids not fat with a strong acid.

Sample for a Test. Whatever the sample to be tested, always eighteen grams are used for a test. In testing cream and cheese, the sample is weighed. For testing milk, skim-milk, buttermilk, and whey, weighing requires

too much time. Indeed, with these substances weighing is not necessary as sufficiently accurate samples are ob-

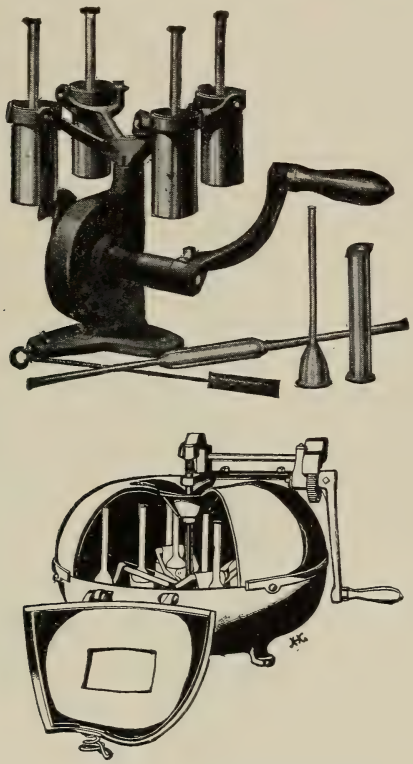


Fig. 8 – Two styles of Babcock testers.

tained by measuring which is the method universally employed. In making a Babcock test it is of the greatest importance to secure a uniform sample of the substance to be tested.

Apparatus. This consists essentially of the following parts: A, Babcock tester; B, milk bottle; C, cream bottle; D, skim-milk bottle; E, pipette or milk measure; F, acid measures; G, cream scales; H, mixing cans; I, dividers.

A. Babcock Tester. This machine, shown in Fig. 8, consists of a revolving wheel placed in a horizontal position and provided with swinging pockets for the bottles. This wheel is rotated by means of a worm wheel (lower machine) at the top of the tester. When the tester stops the pockets hang down allowing the bottles to stand up. As the wheel begins rotating the pockets move out causing the bottles to assume a horizontal position. The wheel is enclosed in a cast iron frame provided with a cover.

B. Milk Bottle. This has a neck graduated to ten large divisions, each of which reads one per cent. Each large division is subdivided into five smaller ones, making each subdivision read .2%. The contents of the neck from the zero mark to the 10% mark is equivalent to two cubic centimeters. Since the Babcock test does not give the percentage of fat by volume but by weight, the 10% scale on the neck of the bottle will, therefore, hold 1.8 grams of fat. In other words, if the scale were filled with water it would hold two grams; but fat being only .9 as heavy, 2 cubic centimeters of it would weigh nine-tenths of two grams or 1.8 grams. This is exactly 10% of 18 grams, the weight of the sample used for testing. A milk bottle is shown in Fig. 9.

C. Cream Bottles. These are graduated from 30% to 55%. A 30% bottle is shown in Fig. 10. Since cream usually tests more than 30%, the sample must be divided when the 30% bottles are used.

Fig. 9.—Milk bottle.

Fig. 10.—Cream bottle.

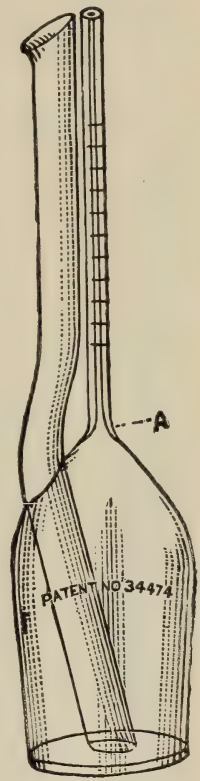


Fig. 11.—Skim-milk bottle.

D. Skim-milk Bottle. This bottle, shown in Fig. 11, is provided with a double neck, a large one to admit the milk, and a smaller graduated neck for fat reading. The entire scale reads one-half per cent. Being divided into ten subdivisions each subdivision reads .05%. The same bottle is also used for testing buttermilk.

Fig. 12.—Pipette.

Fig. 13.—Acid measure.

Fig. 14.—Acid measure.

E. Pipette. This holds 17.6 c.c., as shown in Fig. 12. Since about .1 c.c. of milk will adhere to the inside of the pipette it is expected to deliver only 17.5 c.c., which is equivalent to 18 grams of normal milk.

F. Acid Measures. In making a Babcock test equal quantities, by volume, of acid and milk are used. The acid measure, shown in Fig. 13, holds 17.5 c.c. of acid, the amount needed for one test. The one shown in Fig. 14 is divided into six divisions, each of which holds 17.5 c.c. or one charge of acid. Where

many tests are made a graduate of this kind saves time in filling, but should be made to hold twenty-five charges.

H. A cream scales commonly used is illustrated in Fig. 15.

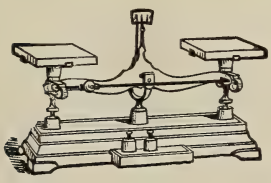


Fig. 15.—Cream scales.

Acid. The acid used in the test is commercial sulphuric acid having a specific gravity of 1.82 to 1.83. When the specific gravity of the acid falls below 1.82 the milk solids are not properly burned and particles of curd may appear in the fat. On the other hand, an acid with a specific gravity above 1.83 has a tendency to blacken or char the fat.

The sulphuric acid, besides burning the solids not fat, facilitates the separation of the fat by raising the specific gravity of the medium in which it floats.

Sulphuric acid must be kept in glass bottles provided with glass stoppers. Exposure to the air materially weakens it.

Fig. 16.—Showing manner of emptying pipette.

Making a Babcock Test. The different steps are indicated as follows:

1. Thoroughly mix the sample.

2. Immediately after mixing insert the pipette into the milk and suck until the milk has gone above the mark on the pipette, then quickly place the fore finger over the

top and allow the milk to run down to the mark by slowly relieving the pressure of the finger.

3. Empty the milk into the bottle in the manner shown in Fig. 16.

4. Add the acid in the same manner in which the milk was emptied into the bottle.

5. Mix the acid with the milk by giving the bottle a slow rotary motion.

6. Allow mixture to stand a few minutes.

7. Shake or mix again and then place the bottle in the tester.

8. Run tester four minutes at the proper speed.

9. Add moderately hot water until contents come to the neck of the bottle.

10. Whirl one minute.

11. Add moderately hot water until contents of the bottle reach about the 8% mark.

12. Whirl one minute.

13. Read test.

Fig. 17.—Fat column showing meniscuses.

How to Read Milk Test. At the top of the fat column is usually quite a pronounced meniscus as shown in Fig. 17. A less pronounced one is found at the bottom of the column. The fat should be read from the extremes of the fat column, 1 to 3, not from 2 to 4, when its temperature is about 140° F. Too high a temperature gives too high

a reading, because of the expanded condition of the fat, while too low a temperature gives an uncertain reading.

Precautions in Making a Test. 1. Be sure you have a fair sample.

2. The temperature of the milk should be about 60 or 70 degrees.

3. Always mix twice after acid has been added.

4. Be sure your tester runs at the right speed.

5. Use nothing but clean, soft water in filling the bottles.

6. Be sure the tester does not jar.

7. Be sure the acid is of the right strength.

8. Mix as soon as acid is added to milk.

9. Do not allow the bottles to become cold before reading the test.

10. Read the test twice to insure a correct reading.

The water added to the test bottles after they have been whirled should be clean and pure. Water containing much lime seriously affects the test. Such water may be used, however, when first treated with a few drops of sulphuric acid.

As stated before, skim-milk, buttermilk, and cream are tested in the same way as milk, with the exception that the cream sample is weighed, not measured. (See p. 51.)

Testing Cream. Accurate tests of cream cannot be secured by measuring the sample into the bottle as is done in the case of milk. The reason for this is that the weight of cream varies with its richness. The richer the cream the less it weighs per unit volume. This is illustrated in the following table by Farrington and Woll:

Weight of fresh separator cream delivered by a 17.6 c. c. pipette.

Per cent. of fat in cream.	Specific gravity (weighed).	Weight of cream in grams.
10	1.023	17.9
15	1.012	17.7
20	1.008	17.3
25	1.002	17.2
30	.996	17.0
35	.980	16.4
40	.966	16.3
45	.950	16.2
50	.947	15.8

With cream testing below 30% the full 18 grams may be added to one bottle and tested in the usual way. Where the cream tests above 30% better results are obtained by using only half the full sample of cream (9 grams) and adding to this 9 grams of water. To this mixture the full amount of acid is added. Obviously in this case the test must be multiplied by 2 to get the correct reading.

General Pointers. Black fat is caused by

1. Too strong acid.
2. Too much acid.
3. Too high a temperature of the acid or the milk.
4. Not mixing soon enough.
5. Dropping the acid through the milk.

Foam on top of fat is caused by hard water, and can be prevented by adding a few drops of sulphuric acid to the water.

Unclean or cloudy fat is caused by

1. Insufficient mixing.
2. Too low speed of tester.
3. Too low temperature.
4. Too weak acid.

Curd particles in fat are caused by

1. Too weak acid.

2. Not enough acid.
3. Too low temperature.

Cleaning Test Bottles. As soon as the test is read, the bottles are emptied by shaking them up and down so as to remove the white sediment. Next wash them in hot water containing some alkali, and finally rinse them with hot water. Occasionally the bottles should be rinsed with a special cleaning solution, which is made by dissolving about one ounce of potassium bichromate in one pint of sulphuric acid. A small brush should also occasionally be run up and down the neck of the bottle.

Reading Cream Tests. Reading the extremes of the fat column, as is done in the case of milk tests, gives too high a reading. This error is due to the meniscus at the top of the fat column, the size of which varies with the width of the neck of the bottle. Farrington and Woll recommend reading from the lowest extremity of the fat column to the bottom of the meniscus. This is the method now commonly employed. Eckles and Wayman recommend removing the meniscus by adding a small quantity of amyl alcohol (colored red) to the top of the fat column. This method gives very satisfactory results.

CHAPTER VI.

CREAMING.

Cause. Creaming is due to the difference in the specific gravity of the fat and the milk serum. The fat being light and insoluble rises, carrying with it some of the other constituents of the milk. The result is a layer of cream at the surface.

Processes of Creaming. The processes by which milk is creamed may be divided into two general classes: (1) That in which milk is placed in shallow pans or long narrow cans and allowed to set for about twenty-four hours, a process known as natural or gravity creaming; (2) that in which gravity is aided by subjecting the milk to centrifugal force, a process known as centrifugal creaming. The centrifugal force has the effect of increasing the force of gravity many thousands of times, thus causing an almost instantaneous creaming. This force is generated in the cream separator.

Shallow-Pan Method. The best results with this method are secured by straining the milk directly after milking into tin pans about twelve inches in diameter and two to four inches deep. It is then allowed to remain undisturbed at room temperature (60° to 65° F.) for twenty-four to thirty-six hours, after which the cream is removed either with a nearly flat, perforated skimmer, or by allowing it to glide over the edge of the pan after it has been carefully loosened along the sides. The average loss of fat in the skim milk by this method is 0.7%.

Deep-Cold-Setting Method. The best results with this method are secured by using a can like the *Cooley* illustrated in Fig. 18. This can is provided with a cover which allows it to be submerged in water. It also has a spout at the bottom by which the skim milk is gently removed, thus preventing the partial mixing of cream and skim milk incident to skimming with a conical dipper.

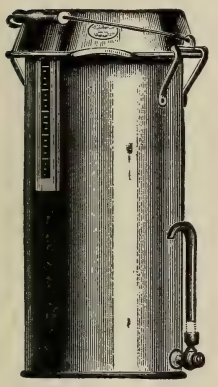


Fig. 18.—Cooley Can.

The milk is put into the cans directly after milking and cooled to as low a temperature as possible. To secure the best results with this method the water should be iced. Where this is done the skim milk will show only about 0.2% fat. It it desirable to allow the milk to set twenty-four hours before skimming, though usually the creaming is quite complete at the end of twelve or fifteen hours.

Dilution or Aquatic Separators. One of the most unsatisfactory methods of creaming is the addition of water to the milk. The creaming by this method is done in variously constructed tin cans, which the manufacturers usually sell under the name of dilution or aquatic separators. Those uninformed about the genuine centrifugal separators are often lead to believe that they are buying *real* separators at a low cost when they are investing five, ten or fifteen dollars in one of these tin cans, which are no more entitled to the term *separator* than are the common shallow pans. The average loss of fat with this system of creaming is about 1½%.

Centrifugal Method (Hand Separator). Dairies having four or more cows should cream their milk by the centrifugal method, the hand separator. The saving of butter fat with this method soon pays for the cost of a separator. Moreover it has the additional advantages over the gravity methods of creaming in providing fresh, sweet skim milk for feeding purposes, and yielding cream of any desired richness.

Efficiency of Creaming With a Separator. Under favorable conditions a separator should not leave more than .05% fat in the skim milk by the Babcock test There are a number of conditions that affect the efficiency of skimming and these must be duly considered in making a separator test. The following are some of these conditions:

A. Speed of bowl.
B. Steadiness of motion.
C. Temperature of milk.
D. Manner of heating milk.
E. Amount of milk skimmed per hour.
F. Acidity of milk.
G. Viscosity of milk.
H. Richness of cream.
I. Stage of lactation. (Stripper's milk.)

A. The greater the speed the more efficient the creaming, other conditions the same. It is important to see that the separator runs at full speed during the separating process.

B. A separator should run as smoothly as a top. The slightest trembling will increase the loss of fat in the skim milk. Trembling of bowl may be caused by any of the following conditions: (1) loose bearings, (2) sepa-

rator out of plumb, (3) dirty oil or dirty bearings, (4) unstable foundation, or (5) unbalanced bowl.

C. The best skimming is not possible with any separator when the temperature falls below 60° F. A temperature of 85° to 98° F. is the most satisfactory for ordinary skimming. Under some conditions the cleanest skimming is obtained at temperatures above 100° F. The reason milk separates better at the higher temperatures is that the viscosity is reduced.

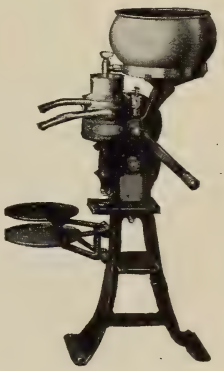


Fig. 19.—Cream Separator.

D. Sudden heating tends to increase the loss of fat in skim-milk. The reason for this is that the fat heats more slowly than the milk serum, which diminishes the difference between their densities. When, for example, milk is suddenly heated from near the freezing temperature to 85° F. by applying live steam, the loss of fat in the skim-milk may be four times as great as it is under favorable conditions.

E. Unduly crowding a separator increases the loss of fat in the skim milk. On the other hand, a marked underfeeding is apt to lead to the same result.

F. The higher the acidity of milk the poorer the creaming. With sour milk the loss of fat in the skim milk becomes very great.

G. Sometimes large numbers of undesirable (slimy) bacteria find entrance into milk and materially increase its viscosity. This results in very unsatisfactory creaming. Low temperatures also increase the viscosity of milk which accounts for the poor skimming at these temperatures.

H. Most of the standard makes of separators will do satisfactory work when delivering cream of a richness of 50%. A richer cream is liable to result in a richer skim-milk. The reason for this is that in rich cream the skim-milk is taken close to the cream line where the skim-milk is richest.

I. Owing to the very small size of the fat globules in stripper's milk, such milk is more difficult to cream than that produced in the early period of lactation.

Regulating Richness of Cream. The richness of cream is regulated by means of a cream screw in the separator bowl. When a rich cream is desired the screw is turned toward the center of the bowl, and for a thin cream it is turned away from the center.

Best Time to Separate Milk. The best results with a separator are obtained by running the milk through the machine immediately after milking.

Saving of Butterfat With a Separator. That the owner of four good cows can afford to invest $50.00 in a small cream separator is shown by the following: Four goods cows will yield not less than 24,000 pounds of milk a year. By the common shallow pan method of creaming, the loss of butterfat will average 0.7 pound for every 100 pounds of milk. With the centrifugal separator the loss of fat will not average over 0.05 pound, hence there will be effected a saving of 0.65 pound of butterfat in each 100 pounds of milk by the use of the separator. At this rate, the total saving of butterfat annually on the 24,000 pounds of milk will be 156 pounds. Since each pound of butterfat will yield approximately 1 1-6 pounds of butter; 183 pounds of butter will be saved by the process, which, at 25 cents per pound,

amounts to $45.75. This saving in butterfat alone will almost pay for the separator in one year.

Fastening a Separator. To secure steady motion, the separator must be fastened to a solid foundation. There is nothing better in this respect than a concrete floor, with which every dairy should be provided.

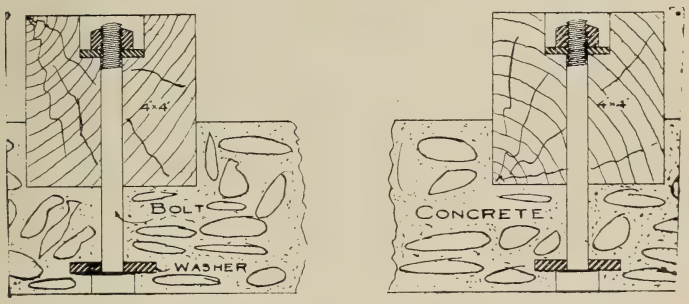


Fig. 20.—Method of Fastening Separator.

There are two common methods of fastening a separator to a concrete floor: One is to fasten two 4x4-inch blocks to the concrete floor as illustrated in Fig. 20. The separator is then fastened to these blocks in the same manner as to a wood floor. The other method of fastening consists in chiseling four conical holes into the concrete floor, at a distance corresponding with the four holes in the separator base. The cavities thus made are filled with babbitt metal, into which holes a little smaller than the lag screws are drilled. The separator is then fastened by turning the lag screws into the babbitt (Fig. 21).

The babbitt may be dispensed with by fastening the bolts with cement as shown at the left in Fig. 21.

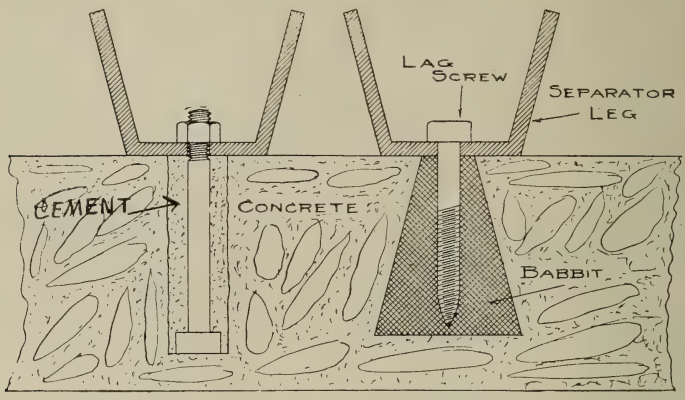


Fig. 21.—Methods of Fastening Separator.

CHAPTER VII.

STANDARDIZING MILK AND CREAM.

This is a process by which milk and cream are brought to a definite percentage of fat.

Reducing Milk and Cream with Skim-milk. Cream producers are called upon to furnish cream of a definite richness, and different grades may be demanded by different buyers. The simplest way to meet such demands is to have the separator deliver cream somewhat richer than the richest grade called for and to reduce this to the required richness by adding skim-milk.

When a definite quantity of cream of a definite richness is to be made up in this way, the following formula will be found simple and direct:

Formula: $\frac{A}{B} \times C = D$, in which

A = test desired.
B = test of original cream.
C = number of pounds of standardized cream.
D = number of pounds of original cream.

Problem: How many pounds each of 45% cream and skim-milk (zero test) are required to make 60 pounds of 18% cream?

Substituting in the above formula we have

$\frac{18}{45} \times 60 = 24 = D$, the amount of original cream to be used.

The amount of skim-milk always equals C — D. Sub-

stituting for C and D in the above problem we have 60—24 = 36, the amount of skim-milk to be used.

The same formula may be used to reduce milk to a lower percentage of fat by adding skim-milk.

Enriching Cream and Milk by Extracting Skim-milk. If milk and cream are too low in fat, they may be made richer by extracting skim-milk according to the following formula:

Formula: $X = A - \frac{A \times B}{C}$, in which

X = number of pounds of skim-milk to be extracted.
A = number of pounds of original milk.
B = test of original milk.
C = test desired.

Problem: How many pounds of skim-milk must be extracted from 450 pounds of 4.0% milk to raise the test to 4.5%.

Substituting in the above formula we have

$$X = 450 - \left(\frac{450 \times 4.0}{4.5}\right) = 50, \text{ the}$$

number of pounds of skim-milk to be extracted.

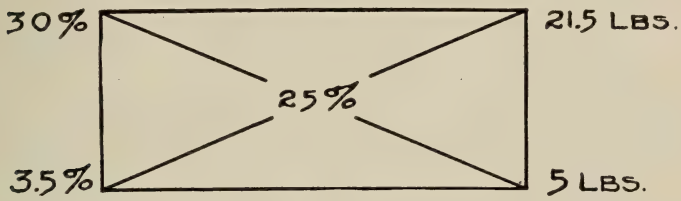
The same formula may be used to enrich cream by extracting skim-milk.

Mixing Two Milks or Two Creams, or Milk and Cream, of Different Richness. In the preceding two formulas the test of the skim-milk was considered zero. When milks or creams of different tests are mixed the calculation becomes more difficult. Pearson, however, has devised a method by which calculations of this kind are very much simplified. This method is as follows:

Draw a rectangle with two diagonals, as shown below. At the left hand corners place the tests of the milks or creams to be mixed. In the center place the richness

desired. At the right hand corners place the differences between the two numbers in line with these corners. The number at the upper right hand corner represents the number of pounds of milk or cream to use with the richness indicated in the upper left hand corner. Likewise the number at the lower right hand corner represents the number of pounds of milk or cream to use, with the richness indicated in the lower left hand corner.

Example: How many pounds each of 30% cream and 3.5% milk required to make 25% cream?



21.5, the difference between 3.5 and 25, is the number of pounds of 30% cream needed; and 5, the difference between 25 and 30, is the number of pounds of 3.5% milk needed.

From the ratio of milk and cream thus found, any definite quantity is easily made up. If, for example, 300 pounds of 25% cream is desired, the number of pounds each of 30% cream and 3.5% milk is determined as follows:

$$21.5 + 5 = 26.5$$

$$\frac{21.5}{26.5} \times 300 = 243.4,$$ the number of pounds of 30% cream.

$$\frac{5}{26.5} \times 300 = 56.6,$$ the number of pounds of 3.5% milk.

CHAPTER VIII.

COLD STORAGE.

Cold storage of some kind is indispensable to a well equipped dairy. Many, however, lack this essential, either because they do not appreciate its importance, or because of the rather high price of commercial refrigerators.

The value of low temperature in keeping milk sweet has frequently been shown by experimental data and is again shown here by the results of a large number of experiments recently conducted by the author. The average results secured in twenty-six experiments show that milk cooled to 45° F. one hour after milking contained 0.19 per cent acid; the same milk kept in the refrigerator at a temperature of 44° F. for fifteen hours showed 0.20 per cent acid, an increase of only 0.01 per cent. In another series of ten experiments milk cooled to 45° F. one hour after milking showed an average of 0.19 per cent acid; the same milk kept in the refrigerator at a temperature of 44° F. for twenty-four hours showed an average of 0.21 per cent acid, an increase of only 0.02 per cent.

These results show that there is practically no development of acid in milk kept at a temperature of 44° F. (Bul. No. 198, N. C. Exp. Sta.)

Ice Box for Small Dairymen. A simple, cheap and effective ice box that will answer the purpose of a refrigerator for small dairymen has recently been constructed

by the author. A detailed description of this box, together with a cross-sectional cut of the same, is herewith

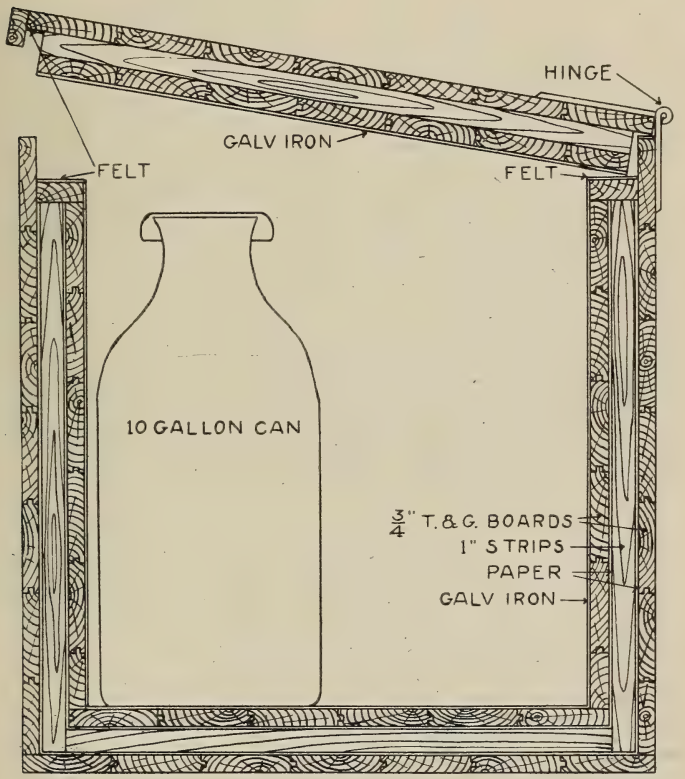


Fig. 22.—Cross-Section of Ice Box.

presented. The dimensions given will answer for a dairy of twenty cows.

The construction of this box, as shown in Fig. 22, consists essentially of two boxes separated by one-inch strips

placed at intervals of about one foot. Double thickness of building paper is placed on both sides of the strips and tacked to the boxes. A one-inch strip, two inches wide, covers the upper space between the one-inch strips, thus making a dead-air space between the two boxes. The construction of the cover is the same as that of the bottom, with the exception that there is a flange at the front and sides of the cover.

The sides, bottom and cover of the refrigerator are built of three-quarter-inch tongued and grooved lumber, five and a half inches wide. The ends are constructed of one and one-eighth inch tongued and grooved flooring three and a half inches wide. The inside of the ice box is lined with galvanized iron. To insure tightness, a layer of felt is tacked around the box and cover where the two meet. The four vertical edges of the box are tightened and strengthened by tacking over each a double layer of paper, which is covered with two 6-inch boards.

A heavy weight attached to a one-half inch rope, running over a pulley fastened to the ceiling, raises the cover and holds it open when desired. A short piece of rope with a hook attached is used to counterbalance the weight by hooking to the front of the box, thus allowing the full weight of the cover to rest on the box.

A short piece of one-half inch gas pipe is inserted through the bottom of the box to provide drainage, the outlet of this pipe being connected with a trap to prevent entrance of air into the box.

The entire construction of the ice box is so simple that any one with a little knowledge of carpentry can readily build it.

The inside dimensions are: Length, 7 1-3 feet; width, 2 1-4 feet; depth, 2 1-3 feet.

An itemized statement of the cost of it is as follows:

200 ft. ¾″ x 5½″—16′ tongued and grooved lumber	$4.00
54 ft. 1⅛″ x 3½″—16′ tongued and grooved lumber	2.16
168 ft. 1″ x 1″—12′ strips	1.26
4 hinges	.60
½ yard felt	.63
15 ft. ½-inch rope	.30
2 strong hooks	.10
1 2-inch iron pulley	.50
Carpentry work, 3 days	6.00
Complete lining with galvanized iron	11.25
500 sq. ft. building paper	.60
Total cost	$27.40

A test of this ice box for six days with an average of 200 pounds of ice in the box showed that an average temperature of 39° F. was maintained within it, with an average daily consumption of 40½ pounds of ice, while the temperature of the room in which the ice box was kept averaged 74° F.

When twenty-two gallons of milk, which had been cooled to 45° F., were stored in the box eight hours daily with the other conditions as above, the average daily ice consumption for six days was 49 pounds, and the average temperature of the box 40° F.

An additional air space could be secured at a small increased expense, and this would not only save ice, but would also make it possible to maintain a somewhat lower temperature than that above indicated.

Refrigerator for Large Dairies. For large dairies a refrigerator like that illustrated in Fig. 23 (original), will be found very satisfactory. The entire inside is finished with concrete making it both durable and sanitary. Two

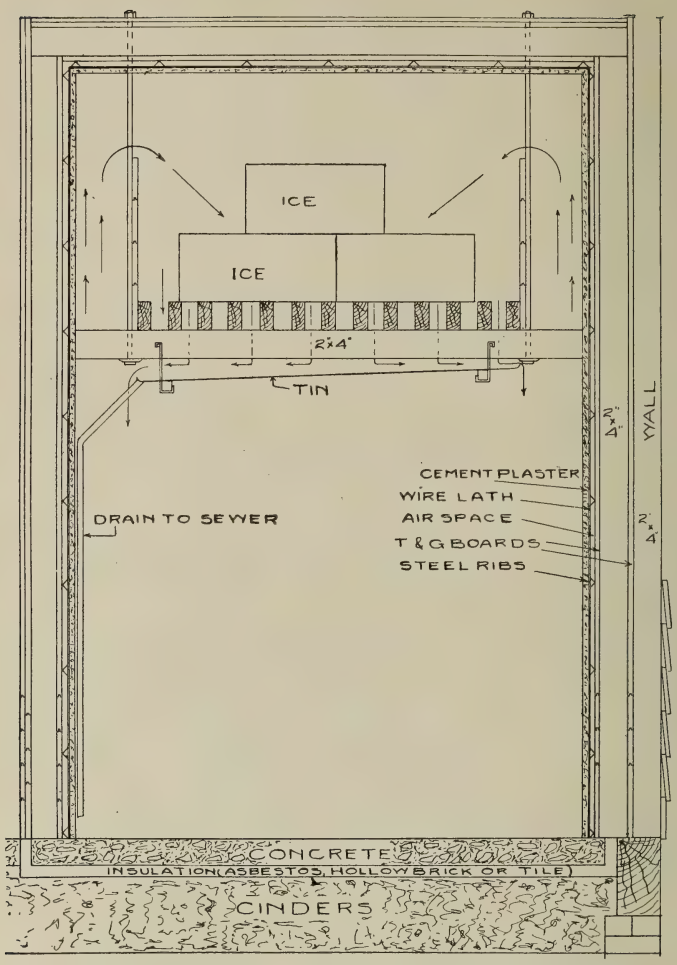


Fig. 23.—Showing Refrigerator and Construction of Dairy House.

dead air spaces are provided: a three-quarter-inch space between the concrete and the boards to which the wire lathing is fastened and a four-inch space between the 2x4-inch studding. These two spaces together with the four layers of paper used, provide a high degree of insulation.

The concrete floor of the refrigerator is constructed upon twelve inches of cinders overlaid with asbestos, both of which materials act as insulators. (See page 133.)

The floor of the ice chamber is built of 2x4-inch studding running the length of the refrigerator. These studs are laid about three inches apart to allow the water from the melting ice to drip through. Below the ice chamber is a shallow pan, which catches the drip from the ice and conducts it either into the sewer or into a cooling tank. The pan is supported by means of two 2x4-inch studs running the full length of the ice chamber. Both ends of the studs are provided with hooks, by means of which the pan is readily attached to, and detached from, the ice chamber. This method of attachment is necessary to permit the easy removal of the pan for cleaning.

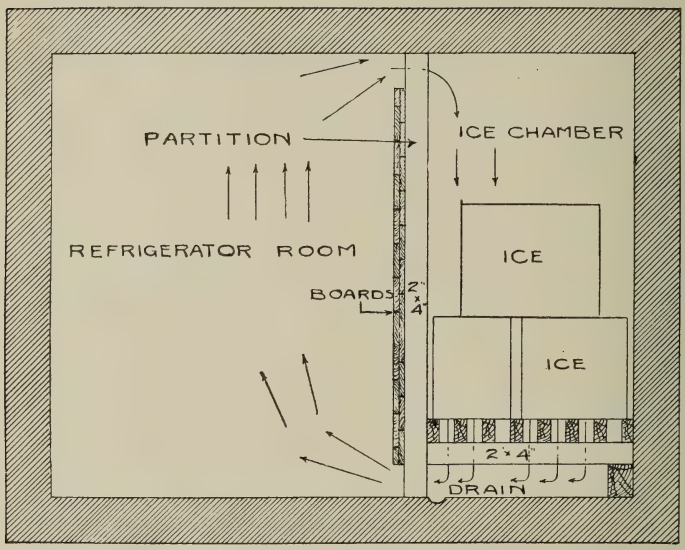
Where a refrigerator of this style is used it is preferably located in the corner occupied by the ice box as shown in the floor plan of the dairy house (Fig. 56, page 131). The rear of the refrigerator is built into the wall of the dairy house in the same way as the side shown in Fig. 23.

The refrigerator must be provided with a door having at least two dead-air spaces and two flanges which fit snugly into the frame of the refrigerator.

The ice is admitted to the ice chamber through a door in the front end of the refrigerator.

Refrigerator Cooled with Ammonia. Such a re-

frigerator may be constructed in the same way as the one described in the preceding pages, with the exception of the ice chamber. In place of this a brine tank and refrigerator coils are used as shown in Fig. 59, page 137. For further particulars regarding this method or refrigeration, see chapter on Mechanical Refrigeration.



Section through Refrigerator Having Ice Chamber at One End.

CHAPTER IX.

HOW TO SECURE A GOOD MARKET.

Quality. As a rule it is easy enough to secure some kind of a market, but to secure the best frequently requires considerable effort. To get fancy prices requires first of all that the product be of superior quality. This is particularly true of milk. The extensive agitation in recent years for clean, pure milk has had the effect of putting a high premium upon such milk. The public is becoming aware of the dangers which lurk in dirty, unsanitary milk and is willing to pay a good price for milk whose wholesomeness is unquestioned.

Value of Advertising. To obtain big prices it is not enough to have products of superior quality, but whatever particular merits they have must be forcibly brought to the attention of consumers. In other words, a certain amount of advertising is necessary.

It is good policy to furnish prospective customers a few free samples and to distribute leaflets describing the conditions under which the products are produced and handled. If the milk is produced in clean, ventilated, whitewashed stables, and from cows which are regularly tested for tuberculosis; if the milk is handled by clean, healthy attendants and is thoroughly cooled and aerated immediately after milking; and if, in addition, all this is certified to by a competent inspector, an increase in prices and patronage is certain to follow when such facts are placed before the public.

The majority of city consumers have little conception of the conditions under which average milk is produced. For this reason the man who is producing clean milk will find it highly profitable to place in contrast vivid pictures of the conditions that yield *average* milk and those that yield *sanitary* milk.

Investigate Outside Markets. Often outside markets offer better prices for milk and cream than does the home market. This is especially true of cream. This product permits of long distance shipping and many outside markets may be glad to get it at fancy prices when the home market may be entirely overstocked.

Dairymen must not expect the market to come to them, however; they must seek the market. A visit or correspondence with managers of cafés, hotels, restaurants, drug stores and ice cream manufactories in different cities, is frequently the means of securing more business and better prices.

Where one is just starting in the dairy business or trying new markets, it is good policy, as a rule, not to ask very high prices at the start. First demonstrate the merits of your products. If these are of a high order consumers will gradually respond to demands for increased prices rather than lose the products. Too high prices at the start are likely to discourage prospective buyers, and thus deprive you of an opportunity to prove the value of your goods.

Uniformity. One of the essentials in building up a good market is uniformity of product. Where this is lacking, improvements in other directions will be of little avail. On the other hand, products which are uniformly the same, week after week, and month after month, are

likely to command good prices even when of only medium quality.

Punctuality. Another essential in building up a good market is punctuality. If your customer expects his milk at 7:30, do not deliver it at 7:40; deliver early rather than late. If you are shipping cream or milk you cannot afford to miss your train—even a single time. It generally means greater disappointment at the other end of the line than one would anticipate.

Try to Please. Always put yourself in an attitude to please. If criticisms come concerning your products, you cannot afford to resent them. Usually there is reason for the criticism. Try to discover the trouble and remedy it.

Delivery Outfit. Cleanliness and neatness must characterize the dairy business throughout. Milk wagons, cans, bottles, drivers, etc., must present a clean appearance. Where they do not, it is usually an easy matter to surmise the condition of milk.

Use a Trade Mark. The name or monogram of the dairy, placed upon the products and delivery wagons, guarantees genuineness and will materially assist in securing a better and more extended market. It is one of the best ways of advertising a superior product.

Secure Your Market Early. If it is intended to sell cream for manufacture into ice cream, it is important to get a market early in the spring. It is difficult to find one in the flush of the ice cream season, because ice cream dealers, as a rule, contract considerably in advance of the time they need the cream. If it is intended to supply winter resorts, apply for the market early in the fall. What has been said here with reference to cream applies also to milk.

Secure Reliable Customers. Where milk and cream are shipped some distance, it is important to determine beforehand the reliability of the buyer. As a rule it is good policy not to make more than three shipments before the first has been paid for. It is well, even where milk and cream are sold locally, to investigate the standings of customers before their accounts have run up very high.

Selling Direct to Consumers. No argument is needed to show the advantage of selling dairy products direct to consumers wherever this is possible. It means the elimination of the middleman whose profits are saved to the dairyman.

Letterhead Stationery. It is not only businesslike to use stationery with a suitable letterhead, but it also serves to advertise the business. The following is submitted as a suitable form of letterhead:

Springdale Sanitary Dairy.
J. C. Boone, Prop.
Dealer in
Pure, Bottled, Jersey Milk and Cream
from Tuberculin Tested Cows.
Reidsville, N. H.....190..

CHAPTER X.

RETAILING MILK AND CREAM.

Dip Method. The old method of hauling milk to the city in five, eight or ten gallon cans and removing each patron's allowance by means of a dipper or faucet, has been found so objectionable that the practice has been largely abandoned. The principal objections to this method are: (1) The admission of dust and bacteria to the milk while measuring it; (2) the use of unsterilized milk vessels by consumers; (3) exposure of the vessels to dust while on the steps of the consumer; (4) the use of unclean vessels by milkmen in measuring each customer's share; (5) lack of uniformity in the milk, especially if removed from the cans by means of a faucet, in which case the first drawn milk is likely to be lowest in fat content; and (6) the possibility of drivers tampering with the milk.

Fig. 24.—Milk Bottle.

The Use of Bottles. Milk and cream intended for retail trade should be put into pint or quart bottles, like that shown in Fig. 24. The advantages of this method are apparent from the fact that the milk is bottled immediately after cooling and that it may be

kept in the same bottle until it is to be consumed. Whenever milk is changed from one vessel to another there is always more or less contamination from dust and bacteria.

Bottling. For dairies having from ten to twenty cows, a can or vat provided with a sanitary faucet will do satisfactory work in filling bottles. A pouring can with a slightly curved spout may also be used for this purpose.

Fig. 25.—Filling Bottles with Machine. (From Da. Div., U. S. Dept. of A.)

For large dairies a bottle filler like that shown in Fig. 25 will be found advantageous. This machine fills six bottles at the same time. Larger or smaller fillers may be had if desired. In selecting a bottle filler secure one of simplest construction and preferably without rubber attachments. This is important for sanitary reasons.

Whatever method of filling is used, it is important to keep the milk well stirred while filling, so as to insure uniform quality in all the bottles.

Immediately after filling, the bottles should be capped with paraffined caps made for this purpose. Fig. 26 illustrates a cap provided with a little handle which facilitates its removal and leaves it intact.

During bottling the room should be kept damp to keep the air free from dust and bacteria. No air current should be allowed to sweep in from the outside. Only clean laundered white suits should be worn by those in charge of the cooling and bottling.

Fig. 26.—Bottle Cap with Handle.

Milk Bottle Delivery Cases. On delivery wagons the bottles are carried in cases holding twelve or more

Fig. 27.—Galvanized Iron Milk Bottle Case.

bottles each. These cases are made of galvanized iron or wood, or of both, and have light removable partitions inside, separating the bottles to keep them from breaking. Galvanized iron cases, like that shown in Fig. 27, are

the most sanitary and also permit putting crushed ice around the bottles.

Fig. 28 shows a galvanized iron milk bottle case, enclosed by a box made of one-inch boards and provided with a tight fitting cover. Cases of this kind should be used in warm weather to keep the milk cool during

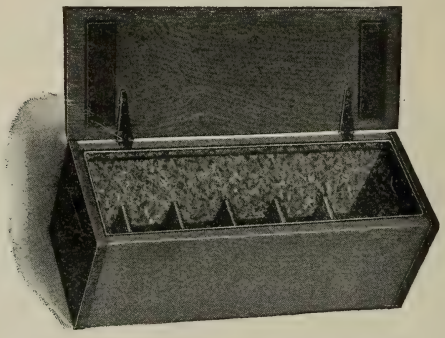


Fig. 28.—Insulated Galvanized Iron Milk Bottle Case.

delivery. On especially warm days, crushed ice should be used around the bottles. This style of case is also recommended where bottles are shipped.

A great deal of milk is spoiled while in transit to the consumer. The last milk delivered on the route may be on the road five or six hours before it finally reaches its destination. If carried in open, uniced cases, on warm days, an exposure of such duration may easily shorten the keeping quality of the milk by eight or more hours.

A matter of prime importance in delivering milk in bottles is to have them thoroughly sterilized before using. Unless this is done milk will not keep long and, what is worse, is likely to disseminate disease along the route.

This danger is due to the bottles' passing from one home to another and eventually reaching a home in which there is some cantagious disease. In such cases there is always a probability that the bottles may become infected with the disease germs.

Frequency of Delivering Milk. When milk is cooled to 45° F. or below immediately after milking and is held at this temperature until it reaches the consumer, one delivery a day is sufficient. If it is desirable, however, to make two deliveries a day, these should be made independent of the milking; that is, the night's milk should be delivered in the morning and the morning's milk in the afternoon.

In some sections, especially in the south, milk is sold with little or no cooling whatever. Hence, the practice of delivering the morning's milk before breakfast, and the night's milk before supper. This practice requires the first milking to be done shortly after midnight and the second milking shortly after midday, a drudgery wholly unnecessary and easily obviated by thoroughly cooling the milk.

Delivery Wagons. These should be clean, covered, well painted, and provided with good springs. The name of the dairy should be printed on each side. A neat and attractive delivery wagon is essential in building up a good trade.

CHAPTER XI.

SHIPPING MILK AND CREAM.

The essential things in shipping milk and cream are cleanliness and low temperature. It is possible to keep milk and cream in good condition for two or three days, if produced and handled under cleanly conditions and

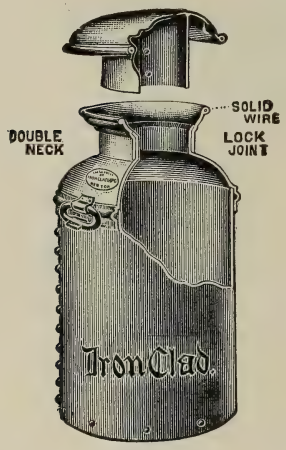


Fig. 29. Milk Can.

Fig. 30.—Felt Jacket on Can.

cooled directly after milking to 40° F. or below. This low temperature must be maintained when long keeping quality is desired. Every dairy should be provided with a good ice box or refrigerator, into which milk and cream

may be placed immediately after cooling and in which they may be kept until ready for shipment.

Shipping in Cans. Various insulated cans are now upon the market and a number of these have been tested by the author. The tests showed that these cans possess about the same insulating effect as the felt jackets that are commonly wrapped around ordinary milk cans. Since the latter, as a rule, are more durable and more easily handled, they will be found more satisfactory when wrapped with a felt jacket than the so-called insulated shipping cans.

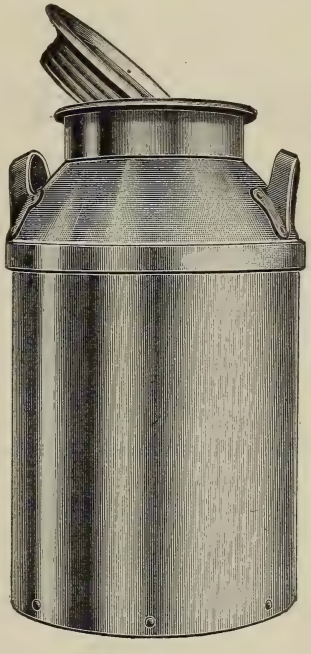


Fig. 31.—Screw Top Can.

When milk and cream are cooled close to freezing and placed in ordinary milk cans wrapped in felt jackets, they may be safely shipped to any point that may be reached within 24 hours even in warm weather. If the temperature of the milk and cream at the time of shipment is 50° F. or higher, then long distance shipment is best accomplished by the use of an ordinary can placed inside of a covered ice cream shipping tub containing ice. Such a tub has practically the same in-

sulating effect as a felt jacket, but is rather heavy and cumbersome and should not be used except in cases where it is necessary to pack ice around the cream or milk. The best results from the ice are secured by packing it in large lumps around the neck of the can.

Shipping in Bottles. Where milk and cream are shipped in bottles, the latter should be placed in insulated delivery cases (Fig. 28) and surrounded with crushed ice. The cases should have the owner's address on them and must be kept locked while in transit.

Mode of Shipping. The usual way of shipping milk and cream is by express. In the main dairy sections baggage rates are available. These rates are lower than express rates and can be obtained nearly everywhere by special arrangement with the railroad companies.

Shipping rates should always be obtained in advance of shipment and the charges should be prepaid. A considerable saving is certain to be effected by rigidly adhering to this practice. Insist upon getting the lowest rates possible.

Pointers on Shipping. Have the name and address of your dairy permanently marked in brass upon every can and cover; also have it sewed or stitched on the felt jackets. This is necessary to insure the return of your own goods. The name and address will be put upon the cans and covers by the dealer from whom they are purchased, if so requested; or, in case unmarked cans are already on the premises, the brass plates with the name and address may be purchased from dairy supply firms and placed upon the cans and covers by a local tinner.

Even when labeled as indicated above, cans will occasionally get lost. Empty cans are usually returned free of charge and, for this reason, express receipts are com-

monly not taken for them. This is a mistake. If the purchaser of your products will take a receipt for the empty cans, the express company becomes responsible for them in the event they are lost. Without the receipt it is next to impossible to claim damages for lost goods.

The empty cans should be washed before they are returned. This should be done for sanitary reasons as well as for the protection of the cans, which are short-lived unless washed and dried immediately after use.

Another matter of importance in shipping is to have the cans full to prevent churning.

Fig. 32.—Lead Seal and Seal Press.

It is necessary also to have the cans sealed to prevent tampering with the contents. The sealing is easily accomplished by means of lead seals and a seal press (Fig. 32).

In delivering the cream or milk at the station the delivery man should see to it that the cans are put in as cool a place as possible.

CHAPTER XII.

WASHING AND STERILIZING MILK VESSELS.

Wash Sinks. A matter of importance in washing milk vessels is to have the right kind of sinks, three of which are needed for the most satisfactory work: One

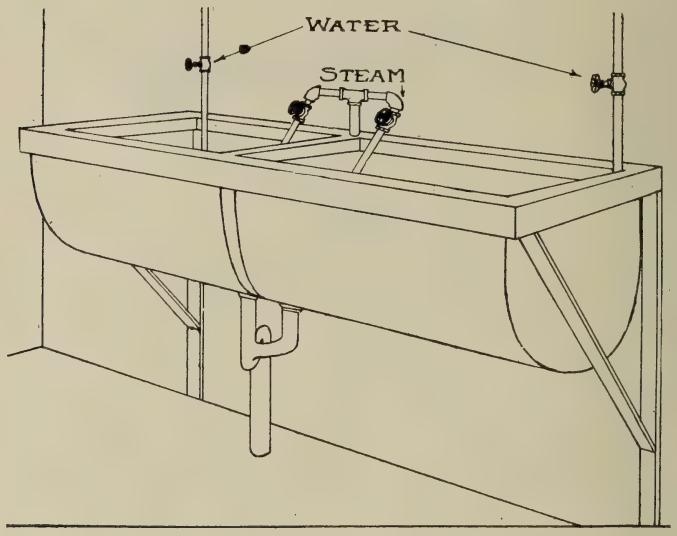


Fig. 33.—Wash Sinks.

for rinsing before washing, one for washing and one for final rinsing.

For convenience the wash sink should be thirty-six

inches long, twelve inches deep, and sixteen inches wide. The bottom should be round and two feet from the floor. When closer to the floor than this too much stooping is required.

Fig. 34.—A Good Cleaning Brush.

Fig. 35.—Milk Bottle Brush.

Galvanized iron furnishes one of the most suitable materials for the construction of wash sinks. They should be provided with steam and cold water pipes as shown in Fig. 33.

Method of Washing. All vessels should be thoroughly rinsed in warm water to remove small residues of milk and cream. The rinsing is followed by washing with moderately hot water to which a handful of some cleaning powder has been added. The washing should be done with brushes rather than cloths because the bristles enter into crevices which a cloth could not possibly reach. Finally rinse the vessels in clean water.

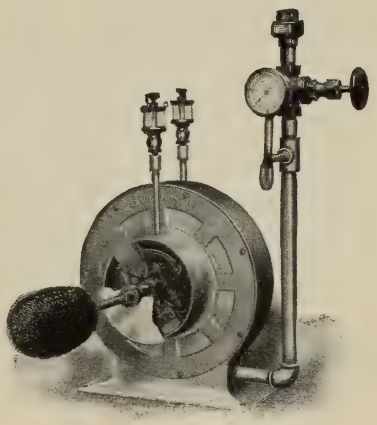


Fig. 36.—Bottle Washer.

A bottle washer, like that shown in Fig. 36, saves much

labor and does very efficient work. The motive power may be either steam or water.

Sterilizing. Vessels that have been washed in the manner described above may look perfectly clean, but may still be far from being free from bacteria. These can be destroyed only by exposing the vessels to the boiling temperature for some time.

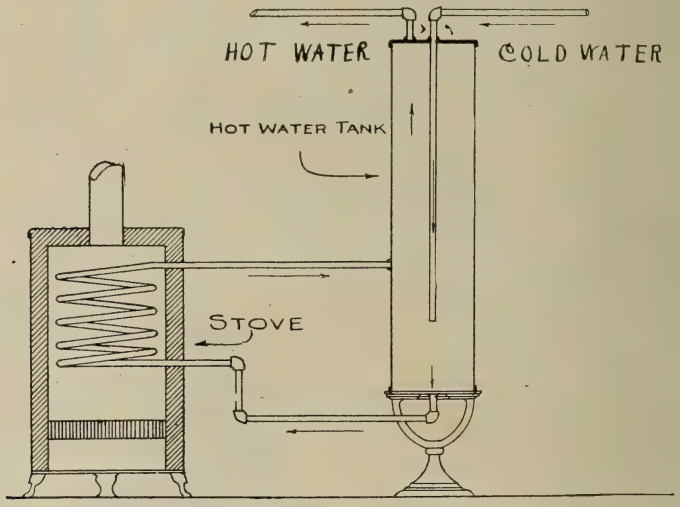


Fig. 37.—Cheap Arrangement for Securing Hot Water.

The simplest method of sterilizing is to place the vessels in boiling water for five minutes. This method commends itself especially to small dairymen who have no steam.

Where no steam is available, the best means of procuring hot water is the apparatus shown in Fig. 37.

The hot water tank is that commonly used in residences for heating water for the bath tub and can be obtained

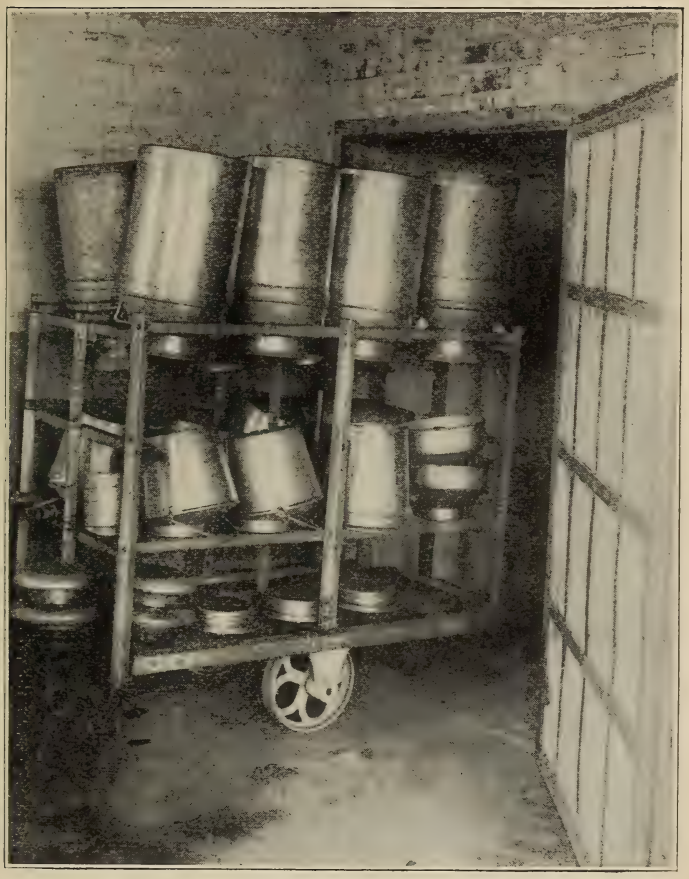


Fig. 38.—Sterilizing Truck and Front of Brick Sterilizer.

from plumbers for about $7.00. Any stove in which iron coils can be heated will answer as a heater.

The best method of sterilizing is to place the vessels

in a steam chamber of sufficient strength to withstand a pressure of ten or more pounds to the square inch. These sterilizers are usually constructed of concrete or brick and

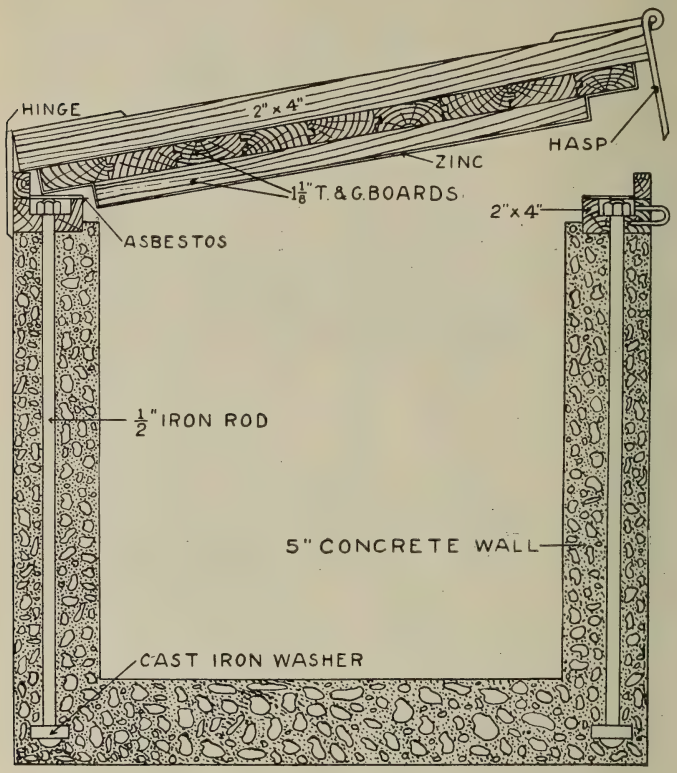


Fig. 39.—Cross-Section of Concrete Sterilizer.

are provided with a heavy iron door which is large enough to admit a truck bearing the pails, cans, bottles, etc. Other sterilizers of this type are constructed of galvanized iron.

The principal drawback to some of these sterilizers is

their high cost, which renders their use by small dairymen almost prohibitive.

Sterilizer Designed by the Author. After considerable study and experimentation, the author succeeded in constructing a simple and efficient concrete sterilizer whose low cost puts it within reach of all dairymen. A section through this sterilizer is shown in Fig. 39.

Essentially, it is a rectangular concrete tank with a wooden cover which is lined with zinc. The sides and bottom are five inches thick and are built of concrete, which is made up of one part cement, two parts sand, and two parts coarse gravel. A thin coat, consisting of one part cement and two parts sand, is used as an inside finish. A piece of 2x4-inch studding is placed around the top of the tank and is secured by six one-half-inch iron rods two feet long, embedded in the concrete walls, one being placed at each corner and one on either side midway between the corners. This arrangement not only strengthens the tank, but also makes the cover fit tighter.

The cover consists of two thicknesses of one and one-eighth-inch tongued and grooved flooring three and one-half inches wide. The upper boards run lengthwise and the lower crosswise of the tank. The lower boards fit into a shoulder projecting from the base of the 2x4-inch studding. The entire inside portion of the cover is covered with zinc. To insure additional tightness of the cover, a layer of asbestos is placed on top of the 2x4s. A heavy weight attached to a one-half inch rope running over a pulley fastened to the ceiling, raises the cover and holds it open when desired. The cover is strengthened by running three pieces of 2x4-inch studding cross-wise of the tank, one at the middle and one at either end. The

hinges by which the cover is fastened are attached to these 2x4s, as shown in Fig. 39.

A safety valve, set at ten pounds pressure, is inserted through the top of the cover at the most convenient place. A bell trap (see Fig. 58) placed in the bottom of the sterilizer serves as an outlet for the condensed steam.

The steam is admitted either through the sides or through the bottom of the sterilizer, and both inlet and outlet pipes should be laid in the concrete at the time the sterilizer is being built.

A false, perforated, metallic bottom is placed one inch from the bottom of the sterilizer, on which all vessels are placed in an inverted position.

The following is an itemized statement of the cost of the material used in the construction of this sterilizer, whose inside dimensions are: length, 7 1-3 feet; width, 2 1-4 feet; depth, 2 1-3 feet.

2 bbls. of Portland cement	$5.20
20 ft. of 2 x 4 studding	.30
110 ft. of 1⅛ tongue and grooved flooring, 3½ wide	4.40
4 hinges	.40
5 lbs. nails	.20
6 ½-inch iron rods 2½ feet long	1.20
3 hasps	.30
20 sq. ft. zinc	1.75
Ball and lever safety-valve	1.00
3 pounds sheet asbestos	.30
Total	$15.05

Sterilizing Bottles. The most convenient way to sterilize bottles is to place them in metallic cases like that shown in Fig. 40. A reversing rack is placed over the cases, which permits sterilizing the bottles in an inverted position.

Importance of Keeping Vessels Inverted. It is not

enough to keep cans, bottles, pails, etc., inverted during sterilization, they should be kept inverted until ready to use. This insures perfect drainage and keeps out dust and bacteria.

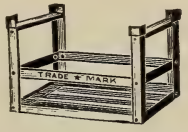


Fig. 40.—Crate for Sterilizing Bottles.

Where hot water is used for sterilizing, the vessels should be inverted on perforated metallic shelves as soon as removed from the water.

Steam Jet. In sterilizing with a steam jet, the vessels are inverted over the end of a steam pipe and steamed for a number of minutes. Though commonly used in the past, the steam jet is much less efficient than either hot water or steam used under pressure in a sterilizer.

CHAPTER XIII.

MAKING AND MARKETING COTTAGE CHEESE.

(Also called curd cheese, smear kase, Dutch cheese, etc.)

In making cottage cheese the first and most important essential is good flavor. Next in importance is uniformity of product. Both of these essentials can be obtained with certainty only by the use of pure cultures of lactic acid bacteria in souring the skim-milk.

The natural souring of milk is due to lactic acid bacteria. Milk always contains these souring organisms, but as a rule, there are present also various other types which produce undesirable flavors. To suppress the undesirable types it is necessary to reinforce the lactic acid organisms by adding large quantities of them in pure form, that is, unmixed with other classes of bacteria. In common parlance such pure cultures of lactic acid bacteria are known as "starters."

METHOD OF USING PURE CULTURES.

The original cultures containing the lactic acid bacteria are prepared commercially and small samples, either in dry or liquid form, can be obtained from the manufacturers at about 75 cents per bottle. The bottle thus obtained is emptied into a quart of *pasteurized* skim-milk, that is, skim-milk which has been kept at a temperature of about 160° F. for 30 minutes and is then quickly cooled to about 70° F. As soon as the quart of skim-milk has

thickened, which usually requires about 24 hours, it is ready for use.

In the heating process all of the active bacteria in the skim-milk have been destroyed, thus leaving a clean field for the development of the lactic acid bacteria added to it from the bottle.

The method of using the lactic acid bacteria is similar to the use of yeast germs in bread making. The original germs obtained from the manufacturer may be propagated for weeks by daily transferring a small amount of the thickened skim-milk to newly pasteurized skim-milk. As a rule, one pound of the thickened skim-milk will sour from 30 to 40 pounds of sweet pasteurized skim-milk in 24 hours at a temperature of 70° F.

When ordering a bottle of culture, ask the manufacturer for full directions for use and follow the directions as closely as possible.

PROCESS OF MAKING COTTAGE CHEESE.

Hitherto no definite method has been employed in the making of cottage cheese which, no doubt, is largely due to the fact that its manufacture has been almost entirely confined to the home. The method in common use consists essentially in placing curdled milk, either heated or unheated, in a linen or cotton bag which is hung up in some convenient place to allow the curd to drain.

Where cheese is to be made on a commercial scale, this method has not been found satisfactory. After much experimentation the author has succeeded in developing a method which has proven very successful in making cheese for city trade. The successive steps in this process are fully treated in the following paragraphs.

Souring the Skim-milk. Where from ten to twenty pounds of cheese are to be made at one time, the skim-milk is most satisfactorily soured in four to eight gallon

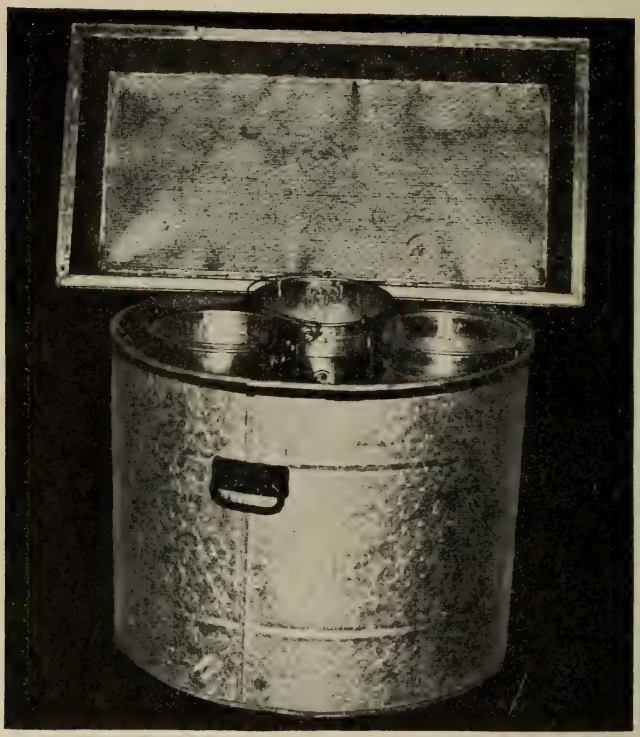


Fig. 41.—Method of Heating Cottage Cheese. Curd Strainer.

shot gun cans, which have a uniform diameter of from eight to ten inches. Enough pure culture of lactic acid bacteria is added to sour the skim-milk in about four hours at a temperature of 100° F. As a rule one gallon

of culture to every four gallons of sweet skim-milk will accomplish the souring in the given time.

The culture should be vigorously stirred and then thoroughly mixed with the skim-milk. As soon as this has been done the cans containing the mixture are placed in a tank of water as shown in Fig. 41. In heating the skim-milk to 100° F. the water in the tank should at no time exceed 110° F. The high temperature employed in souring the skim-milk has several advantages: (1) It hastens the souring process; (2) it causes the skim-milk to curdle with less acid, thus making a milder cheese; and (3) the curd may be stirred at once without danger of diminishing the yield.

Where large quantities of cheese are to be made, the skim-milk should be soured in a common milk, cream or cheese vat.

Heating the Curd. As soon as the skim-milk has thoroughly curdled, the curd should be raised to a temperature of 104° F. by heating the water surrounding it to about 115° F. and care should be taken never to heat the water above 120° F. During the heating process the curd should be constantly stirred with a stirrer consisting of a four-inch heavy tin disc attached to an iron rod. Where a vat is used, the stirring is done by hand. When the curd has reached a temperature of 104° F. the water surrounding it should be removed and the stirring continued for about ten more minutes when it is ready to drain.

Draining the Curd. This is best accomplished in a tin strainer with perforated sides and bottom like that shown in Figs. 41 and 42. The strainer should be of ample size to conveniently hold the curd and to expedite drainage. A piece of cheese cloth should be spread over

the strainer before receiving the curd which must be hand stirred as soon as it reaches the strainer; but the stirring must be done very carefully at the start to avoid loss by mashing the particles.

The stirring should be continued until the curd is firm enough to prevent the particles from sticking together, which usually requires about five minutes. When the proper firmness is reached, it is wrapped in the cloth

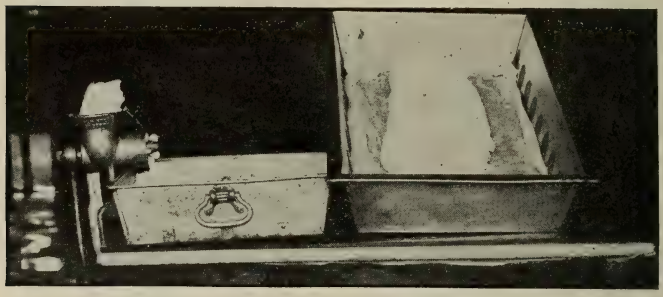


Fig. 42.—Grinding Cottage Cheese. Curd Strainer with Curd.

strainer and squeezed with the hands until most of the whey has been removed. This operation requires only a few minutes, and care must be taken not to press the curd too hard. After pressing, the curd appears in a roll like that shown in Fig. 42.

Grinding the Curd. Immediately after pressing, the curd is run through an ordinary meat grinder, like that shown in Fig. 42. The machine should be set for coarse grinding and should be large enough to enable one to complete the grinding in a few minutes.

Salting and Adding Sweet Milk. The curd is preferably ground into a tin pan, in which it is salted and

treated with sweet whole milk of good quality. Salt is applied at the rate of one ounce for every ten gallons of skim-milk used. It is best to salt lightly, leaving it to the consumer to supply any deficiency. The curd is treated with milk at the rate of one and one-half to two quarts for every ten gallons of skim-milk used. Two-thirds of this is added immediately after grinding, after which the curd is set aside for about two hours, preferably in the refrigerator. This amount of time is necessary

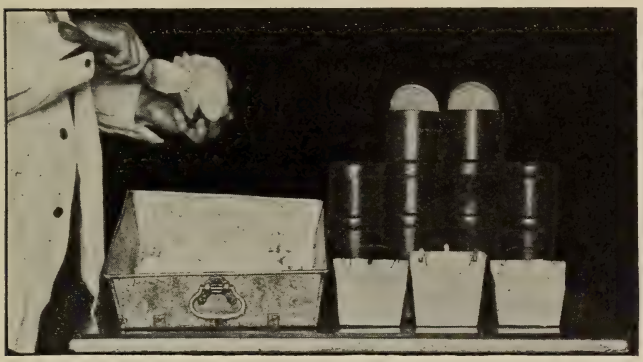


Fig. 43.—Cottage Cheese Packages. Method of Filling Packages.

to permit thorough absorption of the milk. The remaining third of the milk is then added, the curd thoroughly mixed, and immediately packed.

The amount of milk to be added to the curd varies somewhat from day to day, depending upon the amount of moisture left in it at the time of grinding. The rule to follow is to add enough milk to leave the curd fairly wet, but not so wet as to have the milk drip from it.

Packages and Packing. Among a number of styles of packages tried, two have proven very satisfactory;

namely, the Gem Fibre butter package, made of paste-board and lined with parchment paper; and a water-proof paper package commonly used for carrying ice cream. Both of these packages are illustrated in Fig. 43. The round packages are the Gem Fibre, which are easier to pack and better liked by consumers, though they cost somewhat more than the water-proof paper sacks. It was found best to line both packages with parchment paper (11x11 inches) which had been thoroughly soaked in salt brine. Any surplus moisture should be allowed to drip from the paper before putting it into the packages. The latter must also be rinsed in clean water before using, to insure freedom from dust.

The cheese is put into the packages by means of a large spoon, in the manner shown in Fig. 43. One pound packages appear to be the most satisfactory for the average trade.

Yield of Cheese. The average amount of skim-milk required to make a pound of cheese was 7.1 pounds.

Marketing Cottage Cheese. The author has sold large quantities of this cheese to grocers at ten cents per pound, the latter retailing the same at fifteen cents per pound. The grocers were supplied with attractive signs calling attention to the fact that the product was for sale by them. The local press was also used to set forth the nutritive and wholesome qualities of the cheese. Free samples may also be advantageously distributed among prospective customers.

Cottage cheese should be kept at a low temperature from the time it is made until it is consumed. At refrigerator temperature, it may be kept in good condition for several days. The most satisfactory way of disposing of cottage cheese is to sell it direct to the milk

and cream customers along the route daily traveled by the dairyman. This saves the middleman's profits and insures the delivery of the product fresh every day.

How to Serve Cottage Cheese. When the cheese is made according to the author's method, it may be served without any further treatment. Its palatability, however, may be improved by the addition of cream. Additional salt and some pepper is also preferred by some. Others prefer adding sugar or syrup. Caraway and sage are sometimes used to flavor the cheese.

Cottage Cheese as a Food. Cottage cheese when made as herein described, not only has a high food value, but also has tonic or medical qualities which are especially commendable during warm weather. Its nutritive value is nearly the same as that of beefsteak.

CHAPTER XIV.

MAKING AND MARKETING SKIMMILK-BUTTERMILK.

Souring the Skim-milk. As soon as the skim-milk leaves the separator, whole milk is added at the rate of one gallon to twenty gallons of skim-milk. This gives the mixture a fat content, which approximates that of ordinary buttermilk. A large quantity of pure culture of lactic acid bacteria (starter, see p. 90) is next added and the temperature brought to 70° F. Enough starter is added to curdle the skim-milk in about six hours at the temperature mentioned. This requires about one pound of culture for every three pounds of skim-milk. When a temperature above 70° F. is employed, there is a tendency for whey to separate after the skim-milk has curdled.

Churning. When thoroughly curdled, the skim-milk is placed in a churn and churned for about thirty minutes in the same way that cream is churned in making butter. The churning process thoroughly breaks up the curd clots, resulting in a smooth, thick liquid which cannot be distinguished from ordinary good buttermilk.

Cooling. Immediately after the buttermilk leaves the churn, the temperature should be reduced below 50° F. to prevent further development of acid and the separation of the whey. Ordinary milk and cream coolers with enlarged holes in the distributing receptacle will answer very satisfactorily.

Straining. As soon as cooled, the buttermilk should

be run through a strainer consisting of one thickness of cheese cloth to remove any unbroken curd clots.

Bottling. After it is strained the buttermilk is bottled or put in tin cans holding from one to five gallons, after which it is placed in the refrigerator where it is held until ready for delivery.

Marketing Skim-milk Buttermilk. In trying to sell skimmilk-buttermilk it is necessary in the first place, to explain that this product, when made as herein described, is almost identical with the highest grade of natural buttermilk, both in composition and physical properties, and, therefore, in palatability and wholesomeness. Indeed, it is not thought possible under average conditions to secure natural buttermilk of as uniform a quality or as fine a flavor as can be obtained from skim-milk. When these facts are explained to dealers and consumers, any prejudices which might exist against this so-called artificial product are certain to vanish.

The dealers in buttermilk should be furnished with attractive signs, calling attention to the fact that the product is for sale by them. Buttermilk is not found at all soda fountains, and unless conspicuous signs are posted at these places, the public may not call for it.

Buttermilk may readily be sold to drug stores, restaurants, hotels and boarding houses at from ten to thirty cents per gallon, averaging about twelve cents per gallon.

As with cottage cheese, the most satisfactory way of disposing of buttermilk is to sell it direct to the milk and cream customers along the dairy route.

Where buttermilk is intended to be used as a beverage, it is important to keep its temperature below 50° F. until it is consumed.

Food Value of Buttermilk. When used as a bever-

age, buttermilk is usually appreciated only for its palatability. Aside from this, however, it has a high dietetic, as well as high medicinal, value. In certain diseases, especially those affecting the alimentary tract, buttermilk is considered indispensable. Its nutritive value is high, two quarts being approximately equal to one pound of good beefsteak.

Buttermilk From Pasteurized Skim-milk. The best buttermilk is obtained by adding the starter to pasteurized skim-milk. Under such conditions the entire skim-milk becomes virtually a starter or pure culture of lactic acid bacteria. This not only means a better flavor but also insures freedom from pathogenic organisms. Pasteurization also lessens the tendency for the whey to separate.

CHAPTER XV.

MAKING AND MARKETING ICE CREAM.

For the best quality of ice cream use cream containing about 20 % butterfat. Put the cream into a tin can and pasteurize it as follows: Place the can in hot water and stir slowly, but constantly, while heating. As soon as the temperature reaches 150° F. remove the cream from the hot water and let it stand at room temperature from ten to fifteen minutes, then cool quickly to near the freezing temperature.

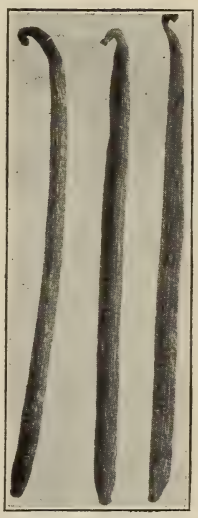


Fig. 44.—Vanilla Beans.

Pasteurization improves the quality of the ice cream, giving it a much smoother body, and also destroys practically all of the bacteria.

Vanilla Flavor. Vanilla is the most popular of ice cream flavors. The best vanilla flavor is obtained by using the best Mexican vanilla bean. Not only does this bean give the best flavor, but it costs less than half as much as the vanilla extracts. The best beans are very oily and pliable, about nine inches long, very fragrant and closed, leaving none of the seeds exposed.

The flavor is prepared by cutting the beans in small

pieces and grinding them with loaf sugar. Immediately after grinding, the vanilla sugar is bottled and corked and set aside until ready for use. On an average one and one-half beans are required per gallon of cream.

Vanilla Ice Cream. In pasteurizing, as soon as the temperature reaches 150° F. add sugar at the rate of one and three-fourths pounds per gallon of cream. This amount includes the vanilla sugar. Next add the vanilla sugar, thoroughly mix, and just before cooling, strain through one thickness of cheese cloth if the seeds are to be retained in the cream, and through four thicknesses if they are to be excluded. The sugar will dissolve much more quickly and the flavor will be more thoroughly abstracted from the ground beans when both are added while the cream is still hot. Hot cream also strains far more quickly than cold.

Freezing. Crush ice to moderate fineness in a strong wooden box with a heavy round stick shaped like a potato masher. Pack this around the freezing can, using three parts of ice to one of ice cream salt. Start the freezer as soon as the cream begins to freeze to avoid crystals. There is danger of churning the cream when the freezer is started while the cream is still warm. As soon as it becomes difficult to turn the freezer longer, remove the beater, scrape all cream from it and pack the cream closely in the can. The cream may now be packed at once into small retail packing cans, or the brine may be removed, more crushed ice and salt added, and the cream kept in the freezer until needed for packing for retail trade.

Lemon Ice Cream. In making lemon flavored ice cream use the best paper-wrapped lemons, free from any signs of decay. Wash the lemons lightly in cold water and grate off the outer, yellowish portion of the rind,

being careful not to grate off any of the white portion which is very bitter. Mix the grated rind with sugar, using one ounce of sugar for each lemon rind. Next cut the lemons in two and squeeze out the juice, removing any seeds that may have dropped in from the squeezer. Mix the juice with the sugared rind and add orange juice to the mixture, using one orange to every five lemons. Allow the mixture to stand for about one hour, stirring it occasionally, and then strain. Use at the rate of one and one-half gills (4 gills = 1 pint) per gallon of cream. The flavor may be beaten into the cream after it is frozen, or it may be added when the cream is partially frozen. The latter is the more convenient method, since the paddles in the freezer will accomplish the mixing.

In making lemon ice cream, use at the rate of two pounds of sugar per gallon of cream, instead of one and three-fourths as for vanilla ice cream. In other respects the cream is treated and handled the same as in making vanilla ice cream.

Packing Ice Cream. Cream that is to be retailed within a day after freezing should be packed into one-quart, two-quart, one-gallon, or larger, packing cans immediately after freezing. The packing cans should be clean, sterile, and cool when the cream is packed into them. Fill them by means of a large spoon or dipper, thoroughly packing the cream so as to leave no air spaces. Put the cover on securely and thoroughly coat the edge with butter to keep out brine. This done, place the packed can of cream in the proper sized tub and pack with ice and salt the same as for freezing, using however most of the salt near the top. It is also better to have the ice somewhat coarser for packing than for freezing.

To eliminate all danger of brine entering the can, it is necessary to have a hole in the tub at a point, say, one inch below the top of the can within it.

If some of the cream is to be held longer than a day after freezing, it is better to leave it packed in the freezer until called for by the consumer. Cream can be kept frozen in bulk more conveniently than in small packing cans, and will require also less ice and salt. Where ice cream is kept in bulk as here indicated, it should not be

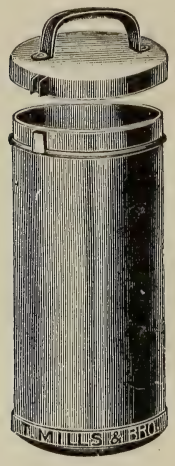


Fig. 45.—Packing Can.

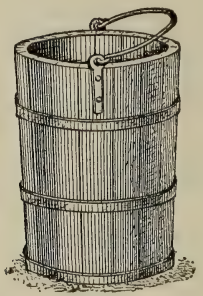


Fig. 46.—Packing Tub.

kept frozen too hard, else there will be difficulty in getting it packed solidly into the small cans.

Ice cream must not be allowed to melt in the packing cans. Remove the brine and repack with ice and salt often enough to prevent melting. In the melting process the water separates and this forms undesirable crystals when the cream is refrozen.

Overrun. This refers to the excess of ice cream over cream. Anything that tends to incorporate and hold air in cream conduces to a large overrun. Thus excessive beating of the cream during freezing mixes a great deal of air with it, and hence increases the overrun. A high viscosity of the cream holds the air incorporated during freezing. Fresh separator cream has a low viscosity, that is, does not whip well, hence will not swell up so much in freezing as cream that has been kept cold for twenty-four hours. Pasteurized cream also has a low viscosity, but this will improve by keeping the cream at a low temperature a number of hours before freezing.

With pasteurized cream and a speed of about eighty revolutions per minute, there will be an overrun of from twenty-five to thirty-three per cent. With unpasteurized cream and a high speed of the freezer, the overrun may be increased to fifty per cent.

Large overruns are always obtained at the expense of quality.

Marketing Ice Cream. Hardly any attempt has yet been made by cream producers living within driving distance of cities to convert their cream into ice cream and sell this product direct to consumers. This is somewhat surprising, since the largest profits in the cream business have hitherto been made by what may be called the middleman, the city ice cream manufacturer.

It is a vital matter with producers to reach consumers direct wherever this is possible, and thus save the middleman's profits. With those who retail milk and cream, the marketing of ice cream would entail no extra expense.

The essential thing in building up a good ice cream trade is to make the best product possible. The market is glutted with cheap, inferior ice cream, and the call

now is for a high grade product. Fortunately the public is beginning to realize that there is positive danger in eating ice cream made from old, stale milk or cream, and the public also seems to begin to understand that the bulk of ice cream is made with so-called thickeners, like gelatine, corn starch, tapioca, arrow root, and others. Many so-called ice creams contain no cream whatever. The highest quality of ice cream contains nothing but good, pure cream, sugar and flavoring.

CHAPTER XVI.

RELATIVE MARKET VALUE OF MILK AND ITS PRODUCTS.

Many milk producers are so situated as to make it possible for them to sell either milk, cream, butter, cheese or ice cream. To those so situated the question naturally arises, what method of disposal will yield the largest returns? This, of course, will depend to a great extent upon the relative market prices of these products.

To show how dairymen may determine for themselves in what form they can realize most for their milk, a simple method of calculation is here presented, in which, for purposes of illustration, the following prices have been adopted: Milk, seven cents per quart; 30% cream, one dollar per gallon; butter, twenty-five cents per pound; cheese, ten cents per pound; and ice cream, made from 15% cream, one dollar per gallon. Using these as average prices for a given locality, determine the relative returns from one hundred pounds of milk containing 4% (4 lbs.) butterfat, (1) when retailed as milk, (2) when sold as cream, (3) when sold as butter, (4) when sold as cheese, and (5) when sold as ice cream.

1. Value of Milk. Since milk weighs 2.15 pounds per quart, 100 pounds of 4% milk are equal to 46.5 quarts, which, at 7 cents per quart, are worth $3.25.

2. Value of Cream. One hundred pounds of 4% milk will make 13.33 pounds of 30% cream, as determined by the following rule:

Rule: To find the number of pounds of cream that can be obtained from a given amount of milk, multiply the milk by its test and divide the product by the test of the cream. Thus the amount of 30% cream from 100 pounds of milk testing 4% equals

$$\frac{100 \times 4}{30} = 13.33 \text{ pounds.}$$

Since a gallon of 30% cream weighs practically the same as a gallon of water (8.35 lbs.), the 13.33 pounds of cream are equal to 1.6 gallons which, at $1.00 per gallon, are worth $1.60. Allowing one-half cent per pound for skim-milk, we have 43 cents as the value of the 86 pounds of skim-milk, which gives a total value of $2.03 for the 100 pounds of 4% milk.

2. Value of Butter. One hundred pounds of 4% milk will yield 4 2-3 pounds of butter, because where up-to-date methods of creaming and churning are followed every pound of butterfat will make 1 1-6 pounds of butter. Four and two-thirds pounds of butter at 25 cents per pound are worth $1.17. Valuing buttermilk at the same price as skim-milk (one-half cent per pound) 48 cents should be added to the $1.17 as the value of the skim-milk and buttermilk, making a total value of $1.65 for the 100 pounds of 4% milk.

4. Value of Cheese. Since one pound of butterfat yields approximately 2.6 pounds of cured cheddar cheese, 100 pounds of 4% milk will make 4×2.6, or 10.4 pounds of cheese, which, at 10 cents per pound, are worth $1.04. Allowing 10 cents as the value of the whey from the 100 pounds of 4% milk, we get a total value of $1.14.

5. Value of Ice Cream. Since a gallon of 15% cream weighs 8.45 pounds, 100 pounds of 4% milk will make 3.15 gallons of 15% cream (see formula for calculating cream, p. 108) or, allowing an overrun of 33 1-3%, 4.2 gallons of ice cream. At $1.00 per gallon this is worth $4.20. To this must be added the value of 73 pounds of skim-milk which, at one-half cent per pound, are worth 37 cents, making a total value of $4.57 for the 100 pounds of milk made into ice cream.

Summary. The preceding calculations show that 100 pounds of 4% milk are worth

$1.14 when sold as cheese,
1.65 when sold as butter,
2.03 when sold as cream,
3.25 when retailed as milk,
4.57 when sold as ice cream.

It is to be remembered that the above figures show the relative gross returns at the prices given. The net returns will vary greatly, depending largely upon the nearness to market and the quantity of milk handled; also to some extent upon the use to which the skim-milk is put. If fed to pigs and calves the value of skim-milk is less than one-half cent per pound; if made into buttermilk or cottage cheese its value may range from one to two cents per pound.

Table of Values. The following table of values has been prepared for handy reference. The price of milk is used as a basis, and the table shows at what prices cream and butter must be sold to give the same returns as milk:

Per Cent. of Fat in Milk	When Milk sells at	20% Cream must sell at	30% Cream must sell at	Butter must sell at
3.5	5c per quart	25c per quart	36c per quart	50c per pound
	6c " "	31c " "	43c " "	60c " "
	8c " "	42c " "	59c " "	84c " "
	10c " "	53c " "	75c " "	$1.06 " "
4.0	5c per quart	22c per quart	31c per quart	44c per pound
	6c " "	27c " "	38c " "	54c " "
	8c " "	37c " "	50c " "	73c " "
	10c " "	46c " "	66c " "	93c " "
4.5	5c per quart	20c per quart	28c per quart	39c per pound
	6c " "	24c " "	34c " "	47c " "
	8c " "	32c " "	46c " "	65c " "
	10c " "	41c " "	59c " "	82c " "
5.0	5c per quart	18c per quart	25c per quart	35c per pound
	6c " "	21c " "	30c " "	43c " "
	8c " "	29c " "	42c " "	59c " "
	10c " "	37c " "	53c " "	75c " "

In calculating the above values, skim-milk and buttermilk have been rated at 30 cents per 100 pounds. The weight allowed per quart is as follows: Milk, 2.15 pounds; 20% cream, 2.1 pounds; and 30% cream, 2.0 pounds. The cost of handling and retailing these products, as well as the cost of making the butter, has not been considered.

From the table it will be seen that when 3.5% milk sells at 5 cents per quart, 20% cream must sell at 25 cents per quart, 30% cream at 36 cents per quart, and butter at 50 cents per pound, to yield equivalent returns. Similarly, when 5% milk sells at 5 cents per quart, 20% cream must sell at 18 cents per quart, 30% cream at 25 cents per quart, and butter at 35 cents per pound.

The table emphasizes the importance of selling milk on the basis of its fat content.

CHAPTER XVII.

FARM BUTTERMAKING.

Cream Ripening. Cream ripening is a process of fermentation in which the lactic acid organisms play the chief role. In every-day language, cream ripening means the souring of the cream. So important is this process that the success or failure of the butter maker is largely determined by his ability to exercise the proper control over it. In common practice the time consumed in the ripening of cream varies from twelve to twenty-four hours.

Since the lactic acid bacteria play such an important part in the production of fine butter, it is obvious that the best results are obtained by ripening the cream with a starter or pure culture of lactic acid bacteria (see page 90). The more starter used in ripening the cream the better the results, provided the ripening is kept under good control.

The sooner the cream is ripened after it leaves the separator the better the quality of the butter. If cream is to be churned every other day, it is best to ripen the first day's cream at once and then hold it at a low temperature until the second day's cream is to be ripened.

Where attempts are made to hold cream sweet several days before ripening it, the undesirable bacteria usually get the upper hand of the lactic acid organisms and the result is the production of undesirable flavors.

Objects of Ripening Cream. The ripening of cream has for its prime object the development of flavor and

aroma in butter, two qualities usually expressed by the word flavor. In addition to this, cream ripening has several minor purposes, namely: (1) renders cream more easily churnable; (2) obviates difficulties from frothing or foaming in churning; (3) permits a higher churning temperature; (4) increases the keeping quality of butter.

Flavor. This, so far as known at the present time, is the result of the development of the lactic fermentation. If other fermentations aid in the production of this important quality of butter, they must be looked upon as secondary. In practice the degree or intensity of flavor is easily controlled by governing the formation of lactic acid. That is, the flavor develops gradually with the increase in the acidity of the cream. Sweet cream butter, for example, is almost entirely devoid of flavor, while cream with an average richness possesses the maximum amount of good flavor possible when the acidity has reached .6%.

Churnability. Practical experience shows that sour cream is more easily churnable than sweet cream. This is explained by the fact that the development of acid in cream tends to diminish its viscosity. The concussion produced in churning causes the little microscopic fat globules to flow together and coalesce, ultimately forming the small granules of butter visible in the churn. A high viscosity impedes the movement of these globules. It is evident, therefore, that anything that reduces the viscosity of cream, will facilitate the churning.

As a rule, too, the greater the churnability of cream the smaller the loss of fat in the buttermilk.

Frothing. Experience shows that ripened cream is less subject to frothing or foaming than unripened. This is probably due to the reduced viscosity of ripened cream and the consequent greater churnability of same.

Temperature. Sour cream can be churned at higher temperatures than sweet cream with less loss of fat in the buttermilk. This is of great practical importance since it is difficult to get low enough temperatures for the successful churning of sweet cream.

Keeping Quality. It has been found that butter with the best keeping quality is obtained from well ripened cream. It is true, however, that butter made from cream that has been ripened a little too far will possess very poor keeping quality. An acidity of .5% should be placed as the limit when good keeping quality is desired.

CONTROL OF THE RIPENING PROCESS.

We have learned that the highly desirable flavor and aroma of butter are produced by the development of the lactic fermentation. In the following discussion we shall take up the means of controlling this fermentation and treat of the more mechanical side of cream ripening. This will include: (1) the ripening temperature; (2) time in ripening; (3) agitation of cream during ripening.

Ripening Temperature. Since the lactic acid bacteria develop best at a temperature of 90° to 98° F. it would seem desirable to ripen cream at these temperatures. But this is not practicable because of the unfavorable effect of high temperatures on the body of the cream and the butter. Good butter can be produced, however, under a wide range of ripening temperatures. The limits may be placed at 60° and 80°. Temperatures below 60° are too unfavorable for the development of the lactic acid bacteria. Any check upon the growth of these germs increases the chances for the development of other kinds of bacteria. But it may be added that when cream has reached an

acidity of .4% or more, the ripening may be finished at a temperature between 55° and 60° with good results. In general practice a temperature between 60° and 70° gives the best results. This means that the main portion of the ripening is done at this temperature. The ripening is always finished at temperatures lower than this.

Time in Ripening. As a rule quick ripening gives better results than slow. The reason for this is evident. Quick ripening means a rapid development of the lactic fermentation and, therefore, a relatively slow development of other fermentations. Practical experience shows us that the growth of the undesirable germs is slow in proportion as that of the lactic is rapid. For instance, when we attempt to ripen cream at 55° F., a temperature unfavorable for the growth of the lactic acid bacteria, a more or less bitter flavor is always the result. This is so because the bitter germs develop better at low temperatures than the lactic acid bacteria.

Stirring Cream. It is very essential in cream ripening to agitate the cream frequently to insure uniform ripening. When cream remains undisturbed for some time the fat rises in the same way that it does in milk, though in a less marked degree. The result is that the upper layers are richer than the lower and will sour less rapidly, since the action of the lactic acid germs is greater in thin than in rich cream.

This uneven ripening leads to a poor bodied cream. Instead of being smooth and glossy, it will appear coarse and curdy when poured from a dipper. The importance of stirring frequently during ripening should therefore not be underestimated.

The Use of Sour Milk (Starter). Cream produced under cleanly conditions ordinarily contains many kinds

of bacteria—good, bad, and indifferent—and to insure a large predominance of the lactic acid type in the ripening process, it is necessary to reinforce the bacteria of this type already existing in the cream by adding large quantities of them in a pure form, that is, unmixed with undesirable species. Clean flavored sour milk or skim milk at the point of curdling is practically a pure culture of lactic acid organisms, and the addition of about 10 pounds of such milk to every 100 pounds of cream will result in a better and more uniform quality of butter.

Amount of Acid to Develop. Cream of average richness should have an acidity of from 0.5 to 0.6 per cent. when churned. A rich cream requires less acid than a thin cream.

Sweet and Sour Cream. In small dairies, where only a few churnings are made weekly, care should be taken never to mix sweet and sour cream just before churning. This always results in a heavy loss of fat in the buttermilk on account of the difference in the churnability of sweet and sour cream.

ACID TEST FOR CREAM.

Butter makers do not find it safe to rely upon their noses in determining the ripeness of cream for churning. They use in daily practice tests by which it is possible to determine the actual amount of acid present. The method of using these tests is based upon the simplest form of titration, which consists in *neutralizing* an *acid* with an *alkali* in the presence of an *indicator* which determines when the point of neutrality has been reached.

In the tests for acidity of cream the alkali used is sodium hydroxide. This is made up of a definite strength

so that the amount of acid can be calculated from the amount of alkali used.

Farrington's Alkaline Tablet Test. In this test the alkali is used in a dry tablet form in which it is easily handled. Each tablet contains enough alkali to neutralize .034 gram of lactic acid.

Apparatus Used for the Test. This is shown in Fig. 47 and consists of a porcelain cup, one 17.6 c.c. pipette, and a 100 c.c. rubber-stoppered, graduated glass cylinder.

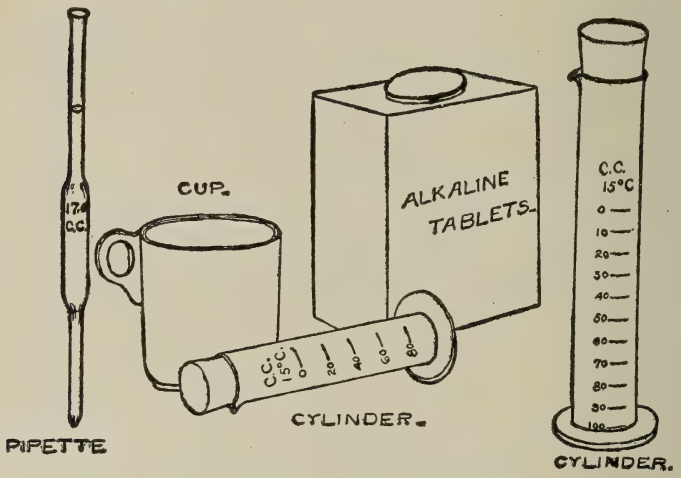


Fig. 47. Farrington Acid Test Apparatus.

Making the Solution. The solution is made in the graduated cylinder by dissolving 5 tablets in enough water to make 97 c.c. solution. When the tablets are dissolved, which takes from six to twelve hours, the solution should be well shaken and is then ready for use. The solution of the tablets may be hastened by placing the graduate in a reclining position, as shown in the cut.

Making the Test. With the pipette add 17.6 c.c. of cream to the cup, then with the same pipette add an equal amount of water. Now slowly add of the tablet solution, rotating the cup after each addition. As soon as a permanent pink color appears, the graduate is read and the number of c.c. solution used will indicate the number of hundredths of one per cent of acid in the cream. Thus, if it required 50 c.c. of the tablet solution to neutralize the cream then the amount of acid would be .50%. From this it will be seen that with the Farrington test no calculation of any kind is necessary.

CHURNING.

Under the physical properties of butter fat it was mentioned that this fat existed in milk in the form of extremely minute globules, numbering about 100,000,000 per drop of milk. In rich cream this number is increased at least a dozen times owing to the concentration of the fat globules during the separation of the milk.

So long as milk and cream remain undisturbed, the fat remains in this finely divided state without any tendency whatever to flow together. This tendency of the globules to remain separate was formerly ascribed to the supposed presence of a membrane around each globule. Later researches, however, have proven the falsity of this theory and we know now that this condition of the fat is due to the surface tension of the globules and to the dense layer of casein that surrounds them.

Any disturbance great enough to cause the globules to break through this caseous layer and overcome their surface tension will cause them to unite or coalesce, a process which we call *churning*. In the churning of cream this

process of coalescing continues until the fat globules have united into masses visible in the churn as butter granules.

CONDITIONS THAT INFLUENCE CHURNING.

There are a number of conditions that have an important bearing upon the process of churning. These may be enumerated as follows:

1. Temperature.
2. Character of butter fat.
3. Acidity of cream.
4. Richness of cream.
5. Amount of cream in churn.
6. Speed of churn.
7. Abnormal fermentations.

1. Temperature. To have the miscroscopic globules unite in churning they must have a certain degree of softness or fluidity, which is greater the higher the temperature. Hence the higher the temperature, within certain limits, the quicker the churning. To secure the best results the temperature must be such as to churn the cream in from thirty to forty-five minutes. This is brought about in different creams at quite different temperatures.

The temperature at which cream must be churned is determined primarily by the character of the butter fat and partly also by the acidity and richness of the cream. Most cream is churned between 55 and 60 degrees Fahr.

Rule for Churning Temperature. A good rule to follow with regard to temperature is this: When the cream enters the churn with a richness of 30 per cent and an acidity of .5 to .6 per cent, the temperature should be such that the cream will churn in from thirty to forty-five minutes. This will insure an exhaustive churning and leave the butter in a condition in which it can be

handled without injuring its texture. Moreover, the buttermilk can then be easily removed, so that when a plug is taken with a trier the day after it is churned the brine on it will be perfectly clear.

2. Character of Butter Fat. The fat globules in cream from different sources and at different times have the proper fluidity to unite at quite different temperatures. This is so because of the differences in the relative amount of "soft" and "hard" fats of which butter fat is composed. When the hard fats largely predominate the butter fat will, of course, have a high melting point. Such fat may be quite hard at a temperature of 60°, while a butter fat of a low melting point would be comparatively soft at this temperature. For a study of the conditions that influence the hardness of butter fat the reader is referred to the discussion of the "insoluble fats" treated in the chapter on milk.

3. Acidity of Cream. This has a marked influence on the churning process. Sour or ripened cream churns with much greater ease than sweet cream because the acid renders it less viscous. The ease with which the fat globules travel in cream becomes greater the less the viscosity. Ripe cream will therefore always churn more quickly than sweet cream. Ripe cream also permits of a higher churning temperature than sweet, which is of great practical importance where it is difficult to secure low churning temperatures.

4. Richness of Cream. It may naturally be inferred that the closer the fat globules are together the more quickly they will unite with the same amount of concussion. In rich cream the globules are very close together, which renders it more easily churnable than thin cream.

The former can therefore be churned in the same length of time at a lower temperature than the latter.

The ideal richness is about 30%. A cream much richer than this will stick to the sides of the churn, which reduces the amount of concussion. The addition of water to the churn will overcome this stickiness and cause the butter to come in a reasonable length of time. It is better, however, to avoid an excessive richness when a exhaustive churning is to be expected.

5. **Amount of Cream in Churn.** The best and quickest churning is secured when the churn is one-third full. With more or less cream than this, the amount of concussion is reduced and the length of time in churning correspondingly increased.

Fig. 48. — Dairy Thermometer.

6. **Speed of Churn.** The speed of the churn should be such as to produce the greatest possible agitation or concussion of the cream. Too high or too low a speed reduces the amount of concussion. The proper speed for each particular churn must be determined by experiment.

7. **Abnormal Fermentations.** The slimy or ropy fermentation sometimes causes trouble in churning by rendering the cream excessively viscous. Cream from single herds may become so viscous as to render churning impossible.

Dairy Thermometer. One of the essentials in making good butter is a thermometer like that shown in Fig. 48. It is necessary to watch the temperature of the cream during ripening, and to secure uniform and exhaustive

churnings the temperature of the cream must always be definitely known before it enters the churn.

CHURNING OPERATIONS.

Churns. Of the numerous styles of churns upon the market there is none better than the barrel churn. For large dairymen, however, who have 50 or more cows, a combined churn and butter worker is recommended. Such churns, of course, require some form of power to run them, and no large dairy is expected to be without power.

Fig. 49.—Barrel Churn.

Preparing the Churn. Before adding the cream, the churn should be scalded with hot water and then thoroughly rinsed with cold water. This will "freshen" the churn and fill the pores of the wood with water so that the cream and butter will not stick.

Straining Cream. All cream should be carefully strained into the churn. This removes the possibility of white specks in butter which usually consist of curd or dried particles of cream.

Adding the Color. The amount of color to be added depends upon the kind of cream, the season of the year and the market demands.

Jersey or Guernsey cream requires much less color than Holstein because it contains more natural color.

During the summer when the cows are feeding on pastures the amount of color needed may be less than half that required in the winter when the cows are feeding on dry feed.

Different markets demand different shades of color. The butter must therefore be colored to suit the market to which it is shipped.

In the winter time about one ounce of color is required per one hundred pounds of butter. During the summer less than one-half ounce is usually sufficient.

In case the color is not added to the cream (through an oversight) it may be added to the butter at the time of working by thoroughly mixing it with the salt. When the colored salt has been evenly distributed through the butter the color will also be uniform throughout.

Gas in Churn. During the first five minutes of churning the vent of the churn should be opened occasionally to relieve the pressure developed inside. This pressure according to Babcock, "is chiefly due to the air within becoming saturated with moisture and not to gas set free from the cream."

Size of Granules. Butter should be churned until the granules are about half the size of a pea. When larger than this it is more difficult to remove the buttermilk and distribute the salt. When smaller, some of the fine grains are liable to pass out with the buttermilk, and the percentage of water in the butter is reduced. When the granules have reached the right size, cold water may be added to the churn to cause the butter to float better. Salt will answer the same purpose. The churn is now given two or three revolutions and the buttermilk drawn off.

Washing Butter. One washing in which as much water is used as there was cream is usually sufficient.

When butter churns very soft two washings may be advantageous. Too much washing is dangerous, however, as it removes the delicate flavor of the butter.

Too much emphasis cannot be laid upon the importance of using clean, pure water for washing. Experiments have shown that impure water seriously affects the flavor of butter. When the water is not perfectly pure it should be filtered or pasteurized.

Salting. It is needless to say that nothing but the best grades of salt should be used in butter. This means salt readily soluble in water and free from impurities. If there is much foreign matter in salt, it will leave a turbid appearance and a slight sediment when dissolved in a tumbler of clear water.

Object of Salting. Salt adds flavor to butter and materially increases its keeping quality. Very high salting, however, has a tendency to detract from the fine, delicate aroma of butter while at the same time it tends to cover up slight defects in the flavor. As a rule a butter maker will find it to his advantage to be able to salt his butter rather high.

Rate of Salt. The rate at which butter should be salted, other conditions the same, is dependent upon market demands. The butter maker must cater to the markets with regard to the amount of salt to use as he does with regard to color.

The rate of salt used does not necessarily determine the amount contained in butter. For instance it is perfectly possible under certain conditions to get a higher percentage of salt in butter by salting at the rate of one ounce per pound than is possible under other conditions by salting at the rate of one and a half ounces. This means that under some conditions of salting more salt is lost than under others.

The amount of salt retained in butter is dependent upon:

1. Amount of drainage before salting.
2. Fineness of butter granules.
3. Amount of butter in churn.

1. When the butter is salted before the wash water has had time to drain away, any extra amount of water remaining will wash out an extra amount of salt. It is good practice, however, to use a little extra salt and drain less before adding it as the salt will dissolve better under these conditions.

2. Small butter granules require more salt than large ones. The reason for this may be stated as follows: The surface of every butter granule is covered with a thin film of water, and since the total surface of a pound of small granules is greater than that of a pound of larger ones, the amount of water retained on them is greater. Small granules have therefore the same effect as insufficient drainage, namely, washing out more salt.

3. Relatively less salt will stick to the churn in large churnings than in small, consequently less will be lost.

Standard Rate. The average amount of salt used in butter is one ounce per pound.

WORKING BUTTER.

Object. The chief object in working butter is to evenly incorporate the salt. It also assists in expelling any surplus moisture.

How to Work Butter. Where only a small amount of butter is made, the butter may be worked with a ladle in the churn. For larger amounts it is desirable, however, to have a separate worker like that shown in Fig. 50.

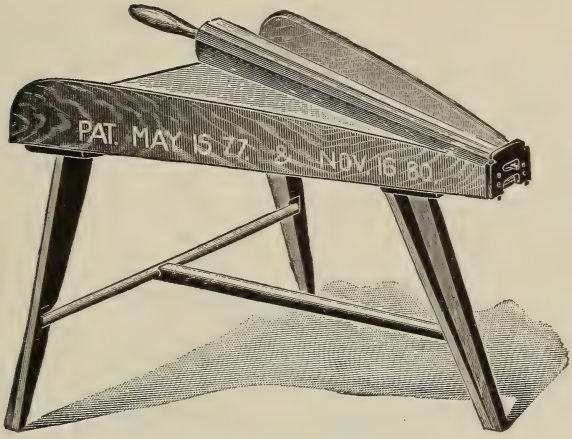


Fig. 50.—Butter worker.

Butter is worked enough when the salt has been evenly distributed. Just when this point has been reached can not always be told from the appearance of the butter immediately after working. But after four or six hours' standing the appearance of white streaks or mottles indicates that the butter has not been sufficiently worked. The rule to follow is to work the butter just enough to prevent the appearance of mottles. To avoid mottles it is best to work butter twice. The first time, it is worked

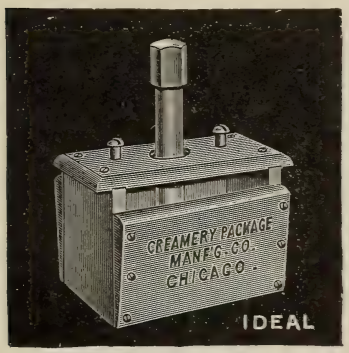


Fig. 51.—Butter Printer.

just enough to fairly incorporate the salt. It is then allowed to stand six or eight hours, after which white streaks are usually noticeable on cutting the butter with a string. The second working should cease as soon as these streaks or mottles have been removed.

Difficult Churning. The causes of trouble in churning may be enumerated as follows: (1) thin cream, (2) low temperature, (3) sweet cream, (4) high viscosity of cream, (5) churn too full, (6) too high or too low speed of churn, (7) colostrum milk, (8) advanced period of lactation, and (9) abnormally rich cream.

Foaming. This is usually due to churning a thin cream at too low a temperature, or to a high viscosity of the cream. When caused by these conditions foaming can usually be overcome by adding warm water to the churn. Foaming may also be caused by having the churn too full, in which case the cream should be divided and two churnings made instead of one.

Cleaning Churns. After the butter has been removed, the churn should be washed, first with moderately hot water, next with boiling hot water containing a little alkali, and finally with hot water. If the final rinsing is done with cold water the churn dries too slowly, which is apt to give it a musty smell. This daily washing should be supplemented occasionally with a washing with lime water.

Nothing is equal to the cleansing action of well prepared lime water and its frequent use will prevent the peculiar churn odor that is bound to develop in churns not so treated.

The outside of the churn should be thoroughly cleaned with moderately hot water containing a *small* amount of alkali.

Marketing Butter. For fancy trade, one-pound prints wrapped in parchment paper are the most popular. These prints are made with a small hand printer (Fig. 51) which should have the dairyman's monogram cut into it. The imprint of the monogram in the butter will serve as a guarantee of its genuineness. It is also desirable to have some neat lettering on the parchment wrapper, such, for example, as Fancy Dairy Butter, Cold Spring Dairy

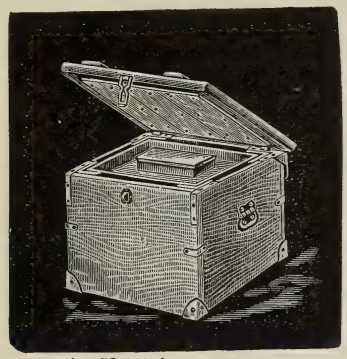


Fig. 52.—Print Butter Box.

Butter, Golden Jersey Butter, etc. Prints must be kept cold to preserve their attractive rectangular appearance.

The best prices for butter are realized by selling it direct to the consumer. With dairymen who retail milk and cream, this method of marketing not only yields the best prices but is also the most convenient, because the butter can be disposed of at the same time as the milk and cream.

A covered box like that shown in Fig. 52 is best adapted for carrying print butter to market. Ice may be packed in the box with the butter during warm weather.

Composition of Butter. According to analysis reported by various experiment stations, American butter has the following average composition:

	Per cent.
Water	13
Fat	83
Proteids	1
Salt	3

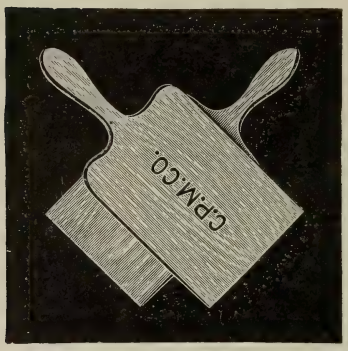


Fig. 53.—Butter Ladles.

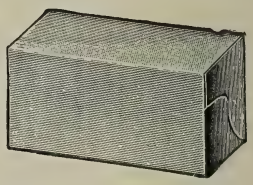


Fig. 54.—Butter Carton for Wrapping One-pound Butter Prints.

CHAPTER XVIII.

THE DAIRY HOUSE.

Location. In selecting a site for a dairy house, convenience and sanitation should be given first consideration. A well drained spot, free from rubbish and bad odors, and within reasonable distance from the barn should be selected. An abundance of good, pure water must be available.

Floor Plans Designed by the Author. Dairymen who sell milk and cream occasionally have a surplus of these products on their hands, which is usually made into butter. Floor plans for dairy houses must therefore provide for small buttermaking outfits in addition to all the necessary apparatus for the handling of milk and cream.

The floor plan shown in Fig. 55 is designed to meet the needs of small dairymen. Figs. 56 and 57 illustrate plans which will answer the needs of dairymen having from twenty to fifty cows. The first two plans provide for natural refrigeration; the last provides for artificial refrigeration. There is no question that refrigerating machinery can be employed very advantageously in a great percentage of the larger dairies.

Details of Construction. The foundation for the walls may be constructed of stone, brick or concrete. It should rest upon firm, solid ground below the frost line, and the top must be at least one foot above ground.

In building the walls, place the studs two feet apart

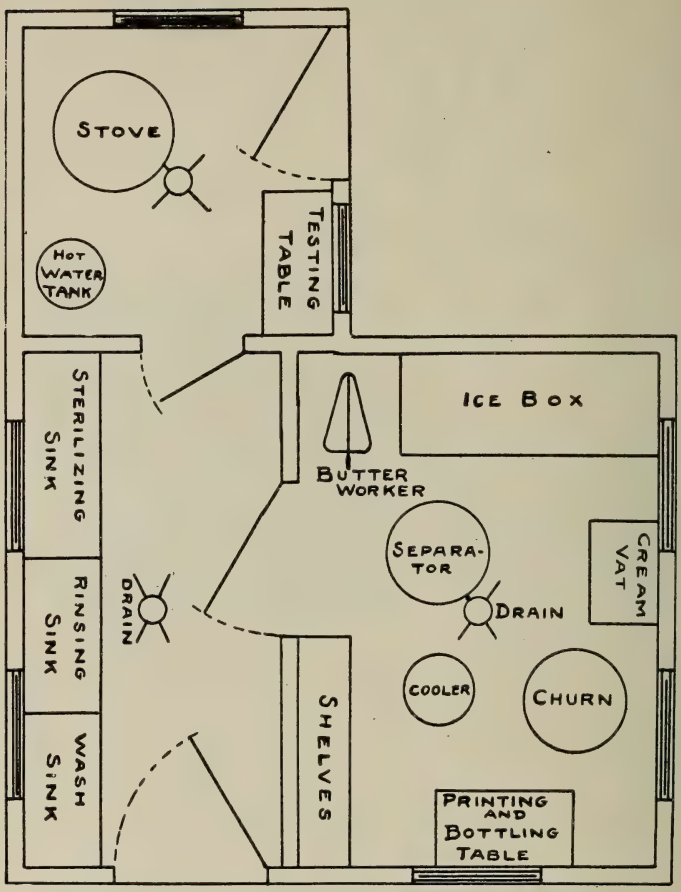


Fig. 55.—Floor Plan of Dairy House Suitable for Ten to Twenty Cows.

and tack building paper on both sides. Weather board the outside and finish the inside as follows: Board up preferably with tongued and grooved lumber, and cover the boards with two thicknesses of

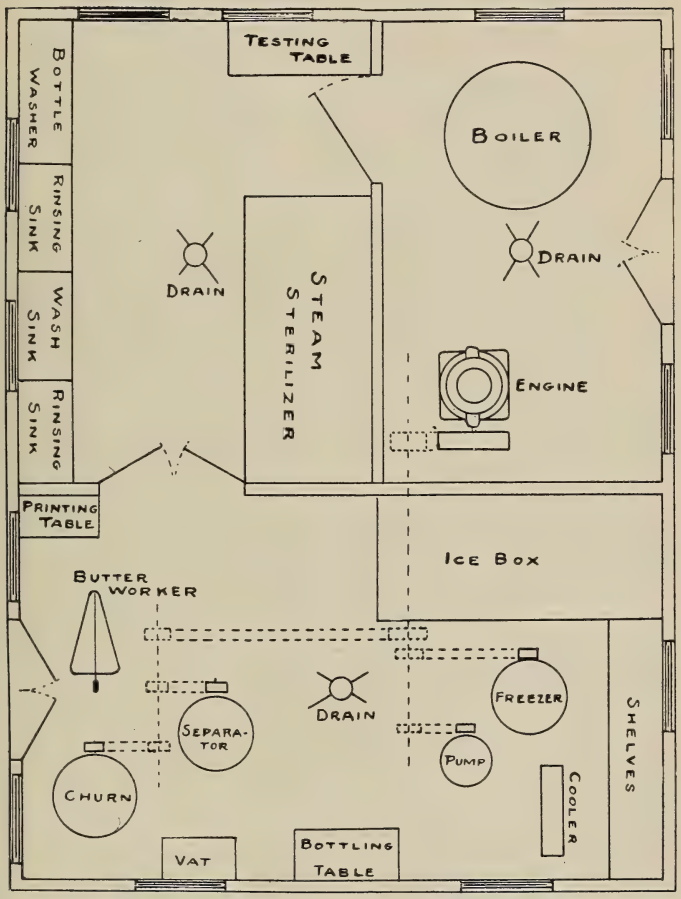


Fig. 56.—Floor Plan of Dairy House Suitable for Twenty to Fifty Cows. (Natural Refrigeration.) 18'x24'.

roofing paper. Next put on furring strips, one foot apart, and to these fasten wire lathing. If the lathing is provided with one-inch steel ribs the furring strips are not

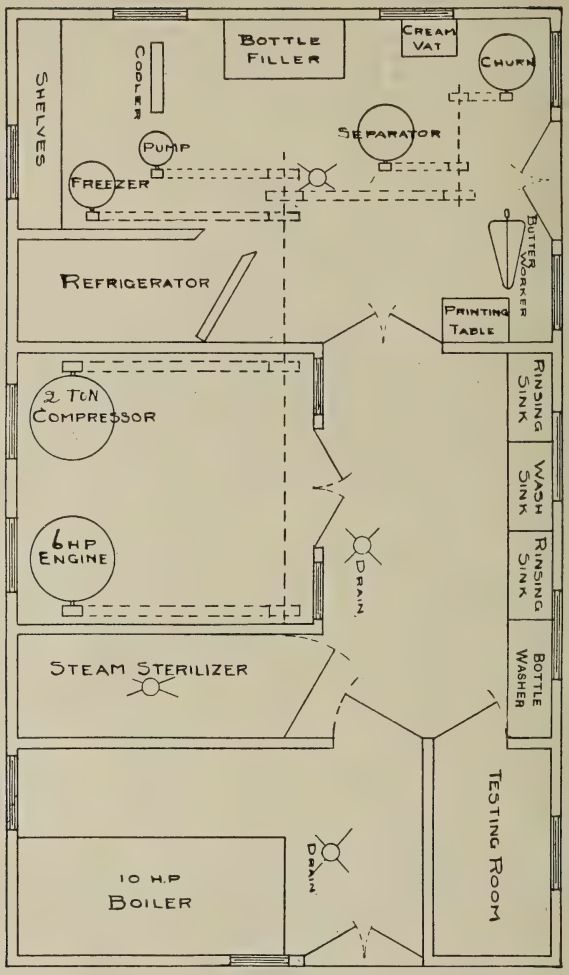


Fig. 57.—Floor Plan of Dairy House Suitable for Twenty to Fifty Cows. (Mechanical Refrigeration.) 18'x30'.

needed. Next apply one and one-half inches of cement plaster consisting of one part cement, three parts clean, coarse sand, and one part slacked lime paste. Press the concrete partly through the wire lathing. Finish with one part cement and one part sand and trowel off as smoothly as possible. This construction provides one three-fourths inch and one four-inch dead air spaces.

The appearance of a wall thus constructed is much improved by coating it with a cement filler which gives it a uniform grayish color. If this is followed by two coats of white enamel laboratory paint, the walls present a very sanitary appearance.

The author has thoroughly tested this enamel paint and has found it very satisfactory. The walls of the milk room especially should be painted with the enamel to within two or three feet of the floor.

Construct a four-inch concrete floor upon a well tamped foundation consisting of gravel, cobble stones and cinders. These materials afford good drainage and thus prevent the cold and dampness usually associated with concrete floors. In preparing the concrete for the floor use one part cement, two parts clean, coarse sand and four parts gravel or crushed stone. Finish with one part cement and two parts sand.

All parts of the floor should slope toward the drain in the center. Round out the corners and edges of the floor with concrete to make them more easily cleanable.

To provide insulation for the concrete floor of the refrigerator, asbestos or other insulating material is used as shown in Fig. 23. The asbestos must be protected from moisture by covering both sides with waterproof paper.

The ceiling should be about twelve feet high and built of the best ceiling lumber. Keep the ceiling well painted.

Enough windows must be provided to afford ample light and to admit sunshine to all parts of the building.

Provide ventilation in the milk and wash rooms by running tight ventilating shafts from the ceiling through the top of the roof.

Sewerage. Effective sewerage must be provided at the time the floor is laid. A bell trap (Fig. 58) should be placed in the center of each room and carefully connected with the sewer. Conduct the sewage far enough away to keep its odors a safe distance from the dairy house. See chapter XXVI.

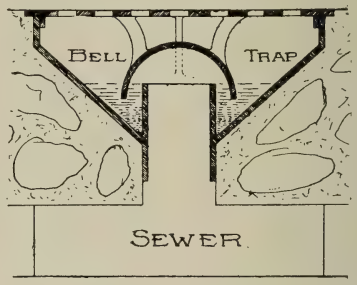


Fig. 58.—Bell Trap.

Method of Warming Dairy Houses. Dairy houses should be heated with steam, not with stoves. Either the exhaust steam from the engine or steam taken directly from the boiler may be used for this purpose. The heating pipes should be so arranged that either may be used when desired.

A very satisfactory method of piping is to run one and one-half inch pipes from the boiler to within two feet of the floor, and close to the walls. The pipes should pass around each room and end in a steam trap which discharges the condensed steam into a hot well located near the injector, so that the hot water may readily be drawn into the boiler. The heating pipes must all slope towards this well.

A *reducing* valve should be placed near the boiler so that any amount of pressure may be carried in the heat-

ing pipes. With a good valve of this kind a pressure as low as one pound may be carried when the boiler pressure varies from twenty to fifty pounds.

Screening. Where proper sanitation is expected it is absolutely necessary to guard against flies, and this can easily be done by screening all doors and windows. Flies are a prolific source of milk contamination and must therefore be rigidly excluded from the dairy.

CHAPTER XIX.

MECHANICAL REFRIGERATION.

In warm climates and in localities where ice is not obtainable or only so at a high cost, cold may be produced by artificial means known as mechanical refrigeration. This system of refrigeration is also finding its way into dairies that are able to procure ice at a moderate cost but which are seeking more satisfactory means of controlling the temperature of their milk, cream and refrigerator. Most of the mechanical refrigerating machines in use at the present time belong to the compression type. Whatever is said here, therefore, will pertain strictly to this class of machines.

Fig. 59 shows a desirable method of piping and also illustrates the circulation of the ammonia. The milk and cream are cooled with cold brine which is circulated by means of a pump. No ice is needed. When an especially low temperature of the brine is desired, as in making ice cream, valves A (Fig. 59) are shut off and valves B opened, leaving all of the ammonia to circulate through the brine tank.

Principle of Refrigeration. The principle employed in mechanical refrigeration is the production of cold by the evaporation of liquids which have a low boiling point, like liquid ammonia, liquid carbonic acid, ether, etc.

When a liquid evaporates or changes into the gaseous state it absorbs a definite amount of heat called heat of

vaporization or "latent" heat. Thus to change water from 212° F. to steam at 212° F. requires a considerable amount of heat which is apparently lost, hence the term latent (hidden) heat.

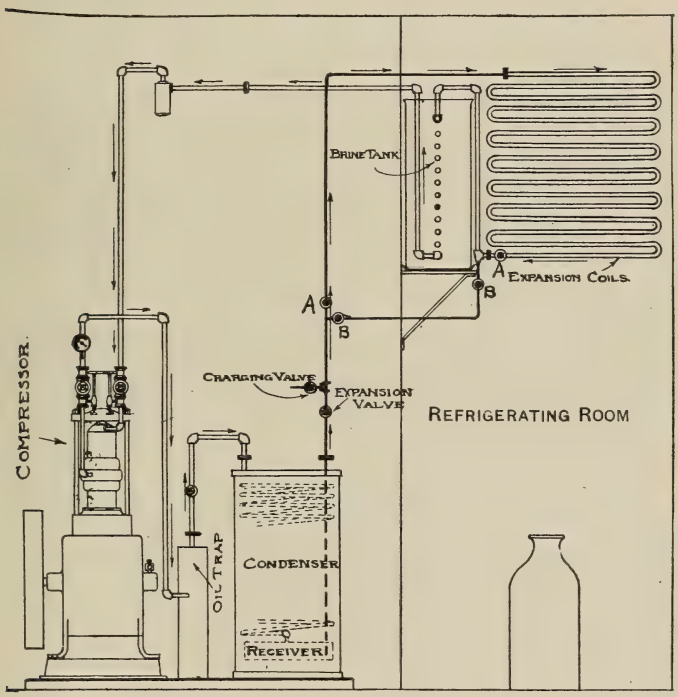


Fig. 59.—Showing Circulation of Ammonia in Mechanical Refrigeration.

Ether changes into its gas at a much lower temperature than water which is illustrated by its instant evaporation when poured upon the hand. The heat of the hand in this case is sufficient to cause vaporization and the sensation of cold indicates that a certain amount of heat has been abstracted from the hand in the process.

Manifestly for refrigerating purposes a liquid must be used that can be evaporated at a very low temperature; for the cold in mechanical refrigeration is produced by the evaporation of the liquid in iron pipes, the heat for the purpose being absorbed from the room in which the pipes are laid. Anhydrous ammonia has thus far proven to be the best refrigerant for ordinary refrigeration.

Anhydrous Ammonia (Refrigerant). This substance is a gas at ordinary temperatures but liquifies at 30° F. under one atmospheric pressure. In practical refrigeration the ammonia is liquified at rather high temperatures by subjecting it to pressure. The ammonia is alternately evaporated and liquified so that it may be used over and over again almost indefinitely.

Circulation of Ammonia. The cycle of operations in mechanical refrigeration is as follows: The liquid ammonia starts on its course from a *liquid receiver,* and enters the *refrigerating coils* in which it evaporates, absorbing a large amount of heat in the process. By means of a *compression pump,* operated by an engine, the ammonia vapors are forced in the *condenser coils* where the ammonia, under pressure, is again liquified by running cold water over the coils. From the condenser coils it enters the liquid receiver, thence again on its journey through the refrigerating coils.

The intensity of refrigeration is regulated by an *expansion valve,* which is placed between the liquid receiver and the refrigerating coils. This valve may be adjusted so as to admit the desired quantity of liquid ammonia to the coils.

Systems of Refrigeration. There are two ways in which the cooling may be accomplished by mechanical refrigeration: (1) by evaporating the liquid ammonia

in a series of pipes placed in the room to be refrigerated; and (2) by evaporating the liquid ammonia in a series of coils laid in a tank of brine and using the cold brine for cooling purposes. The former is known as the direct expansion system, the latter as the indirect expansion or brine system.

Brine System. Brine should be exclusively used for cooling milk and cream and also largely for cooling the refrigerator. It is desirable, however, to have a few direct expansion coils in the refrigerator which may be used when extra cold is desired. The brine tank is located near the ceiling in the refrigerator where it will serve the same purpose as an overhead ice box. Refrigerating pipes may also be laid in the milk room for the purpose of controlling its temperature during the warm summer months.

The brine is kept circulating by means of a *brine pump*.

Strength of Brine. The brine is usually made from common salt (sodium chloride). The stronger the brine the lower the temperature at which it will freeze. Its strength should be determined by the lowest temperature to be carried in the brine tank. The table by Siebel on the next page shows the freezing temperature as well as the specific heat of brine of different strengths.

The fact that the specific heat grows less as the brine becomes stronger shows it to be wise not to have the solution stronger than necessary, because the less the specific heat the less heat a given amount of brine is able to take up.

Per centage of salt by weight.	Pounds of salt per gallon of solution.	Freezing point (F.).	Specific heat.
1.	0.084	30.5	.992
2.	0.169	29.3	.984
3.	0.256	27.8	.976
4.	0.344	26.6	.968
6.	0.523	23.9	.946
8.	0.708	21.2	.919
10.	0.897	18.7	.892
12.	1.092	16.0	.874
15.	1.389	12.2	.855
20.	1.928	6.1	.829
25.	2.488	0.5	.783
26.	2.610	-1.1	.771

Refrigerating Capacity. To speak of a machine of one ton refrigerating capacity, means that it will produce, in the course of twenty-four hours, the amount of cold that would be given off by one ton of ice at 32° F. melting into water at the same temperature. Its actual ice making capacity is about 50% less.

Size of Compressor. If the equivalent of five hundred pounds of ice is needed per day, then a half ton compressor will answer, provided it is run twenty-four hours a day. But since it will not likely be convenient to run the compressor more than six hours a day, a machine four times this size will be necessary. The larger the compressor the shorter the time it needs to be run. A two-ton refrigerating machine will be large enough for a fifty-cow dairy.

Power Required to Operate. The power required per ton of refrigeration is less the larger the machine. With a two-ton compressor, the power required is about two and one-half horsepower per ton of refrigerating capacity in twenty-four hours.

Refrigerating Pipes. The refrigerating pipes vary from one to two inches in diameter. With moderately good insulation it is estimated that by the direct expansion system one running foot of two-inch piping will keep a room of forty cubic feet content at a temperature of 32° F. With brine nearly twice this amount of piping would be necessary.

For cooling the brine in the brine tank, about 140 feet of 1¼-inch pipes are required per ton of refrigerating capacity.

Expense of Operating. When a refrigerating plant has once been installed and charged with the necessary ammonia, the principal expense connected with it will be the power required to operate the compressor. This power is supplied by the engine that is used for the regular dairy work. The ammonia, being used over and over again, will add but a trifle to the running expenses. Nor can the water used for cooling the ammonia vapors add much to the cost of operating. It is true, however, that the refrigerating plant will require some of the dairyman's time and attention, but this is probably no more than would be consumed in the handling of ice in the dairy.

Charging and Operating an Ammonia Plant. This subject is so ably discussed in *The Engineer* by H. H. Kelley that the author feels he can do no better than present the following extracts from that article.

"When about to start an ice or refrigerating plant, the first thing necessary is to see that the system is charged with the proper amount of ammonia. Before the ammonia is put in, however, all air and moisture must be removed; otherwise the efficiency of the system will be seriously interfered with. Special valves are usually provided for

discharging the air, which is removed from the system by starting the compressor and pumping the air out, the operation of gas cylinder being just the reverse of that when it is working ammonia gas. It is practically impossible to get all the air out of the entire system by this means, so that some other course must be taken to remove any remaining air after the compressor has been started at regular work. This can be accomplished by admitting the ammonia a little at a time, permitting the air to escape through a purge valve, the air being thus expelled by displacement. The cylinder containing the anhydrous ammonia is connected to the charging valve by a suitable pipe, and the valve opened. The compressor is then kept running slowly with the suction and discharge valves wide open and the expansion valve closed. When one cylinder is emptied put another in its place, being careful to close the charging valve before attempting to remove the empty cylinder, opening it when the fresh cylinder is connected up.

"From sixty to seventy-five per cent of the full charge is sufficient to start with so that the air may have an opportunity of escaping with as little loss of ammonia as possible. An additional quantity of ammonia may then be put in each day until the full charge has been introduced. When the ammonia cylinders have been emptied and a charge of, say, seventy-five per cent of the full amount has been introduced, the charging valve is closed and the expansion valve opened. The glass gauge on the ammonia receiver will indicate the depth of ammonia. The appearance of frost on the pipe leading to the coils and the cooling of the brine in the tank will indicate that enough ammonia has been introduced to start with. It is sometimes difficult to completely empty an ammonia cylin-

der without first applying heat. The process of cooling being the same when the ammonia expands from the cylinder into the system as when leaving the expansion valve, a low temperature is produced and the cylinder and connections become covered with frost. When this occurs the cylinder must be slightly warmed in order to be able to get all the ammonia out of it. The ammonia cylinders, when filled, should never be subjected to rough handling and are preferably kept in a cool place free from any liability to accident. The fact that ammonia is soluble in water should be well understood by persons charging a refrigerating system, or working about the plant. One part of water will absorb about 800 parts of ammonia gas and in case of accident to the ammonia piping or machine, water should be employed to absorb the escaping gas. Persons employed about a plant of this kind should be provided with some style of respirator, the simplest form of which is a wet cloth held over the mouth and nose.

"After starting the compressor at the proper speed and adjusting the regulating valve note the temperature of the delivery pipe, and if there is a tendency to heat open it wider, and vice versa. This valve should be carefully regulated until the temperature of the delivery pipe is practically the same as the water discharged from the ammonia condenser. With too light a charge of ammonia the delivery pipe will become heated even when the regulating valve is wide open. As a general thing when the plant is working properly the temperature of the refrigerator is about 15° lower than the brine being used, the temperature of the water discharged from the ammonia condenser will be about 15° lower than that of the condenser, the pointers on the gauges will vibrate the same distance at each stroke of the compressor and the

frost on the pipes entering and leaving the refrigerator will be about the same. By placing the ear close to the expansion valve the ammonia can be heard passing through it, the sound being uniform and continuous when everything is working properly.

"When air is present the flow of ammonia will be more or less intermittent, which irregularity is generally noticeable through a change in the usual sound heard at the expansion valve. The pressure in tne condenser will also be higher and the effect of the apparatus as a whole will be changed, and, of course, not so good. These changes will be quickly noticed by a person accustomed to the conditions obtaining when everything is in order and working properly.

"The removal of air is accomplished in practically the same manner as when charging the system, permitting it to escape through the purging valve a little at a time so as not to lose any more gas than is absolutely necessary.

"The presence of oil or water in the system is generally detected by shocks occurring in the compressor cylinder.

"In nearly all plants the presence of oil in the system of piping is unavoidable. The oil used for lubricating purposes, especially at the piston rod stuffing boxes, works into the cylinders and is carried with the hot gas into the ammonia piping, where it never fails to cause trouble. The method of removing the air from the system has already been referred to, but the removal of oil is accomplished by means of an oil separator. This is placed in the main pipe between the compressor and the condenser, and is of about the size of the ammonia receiver. Sometimes another oil separator is placed in the return pipe close to the compressor which serves to eliminate any remaining oil in the warmer gas and to remove pieces of

scale and other foreign matter which, if permitted to enter the compressor cylinder, would tend to destroy it in a very short time.

"The oil, which always gets into the system sooner or later and in greater or less quantity, depending upon the care exercised to avoid it, acts as an insulator and prevents the rapid transfer of heat from the ammonia to the pipe that ought to obtain, and also occupies considerable space that is required for the ammonia where the best results are to be obtained."

CHAPTER XX.

KEEPING ACCOUNTS.

Various methods are followed in keeping accounts with patrons, but nearly all of them involve the use of tickets, route book, and some form of ledger. The method here described is recommended because of its simplicity.

Tickets. Most customers prefer to settle their milk and cream accounts daily. This they do by purchasing a quantity of tickets from the milkman and handing them out every time milk or cream is purchased.

The tickets should be used but once. Where they are repeatedly used they become dirty and a real source of danger. Passing from one household to another they are likely to become contaminated with disease germs and thus become the means of disseminating disease.

The coupon ticket presented on the next page is one of the most satisfactory in use at the present time. The portion of the ticket above the perforations is retained by the milkman. If the ticket is paid for at the time of purchase, this must be indicated on the stub retained by the dairyman as well as on the customer's ticket.

Coupon tickets are also used for cream and buttermilk. Tickets for different products should have different colors.

Tickets are not absolutely necessary; indeed, many customers prefer to do without them. Where no tickets are

No. 45 Date Dec. 2 1908

Mr. C. Eaton

102 Elm St.

To TICKETS $1.00. MILK. Cr. 1.00

MILK.

No. 45 Date Dec. 2 1908

Mr. C. Eaton

To SPRING VALLEY DAIRY, Dr.

J. L. JONES, Prop., Middleton, N. Y.

To TICKETS $1.00.

Received Payment J. L. Jones

Date Dec. 2 1908

ONE PINT. SPRING VALLEY DAIRY. ONE QT. MILK MIDDLETON, N. Y. ONE PINT.	ONE PINT. SPRING VALLEY DAIRY. ONE QT. MILK MIDDLETON, N. Y. ONE PINT.
ONE PINT. SPRING VALLEY DAIRY. ONE QT. MILK MIDDLETON, N. Y. ONE PINT.	ONE PINT. SPRING VALLEY DAIRY. ONE QT. MILK MIDDLETON, N. Y. ONE PINT.
ONE PINT. SPRING VALLEY DAIRY. ONE QT. MILK MIDDLETON, N. Y. ONE PINT.	ONE PINT. SPRING VALLEY DAIRY. ONE QT. MILK MIDDLETON, N. Y. ONE PINT.
ONE PINT. SPRING VALLEY DAIRY. ONE QT. MILK MIDDLETON, N. Y. ONE PINT.	ONE PINT. SPRING VALLEY DAIRY. ONE QT. MILK MIDDLETON, N. Y. ONE PINT.
ONE PINT. SPRING VALLEY DAIRY. ONE QT. MILK MIDDLETON, N. Y. ONE PINT.	ONE PINT. SPRING VALLEY DAIRY. ONE QT. MILK MIDDLETON, N. Y. ONE PINT.

Coupon Ticket.

used, an account is rendered at the end of the month similar to that rendered by the grocer.

Route Book. It is evident that if customers were always supplied with tickets and regularly paid for each delivery of milk or cream, no further record would be necessary. But customers will run out of tickets occasionally as well as forget to regularly hand them out, hence it is necessary for drivers to carry with them a record or route book in which each transaction is recorded at the time it is made. A form suitable for this purpose is shown below.

Adamson, C. F										Anson, C. R									
JANUARY. 1902.	CASH PAID	MILK		CREAM		B M		BOTTLES.		CASH PAID	MILK.		CREAM.		B. M		BOTTLES.		
		QUARTS.	TICKETS.	PINTS.	TICKETS.	QUARTS.	TICKETS.	DELIVERED.	RETURNED.		QUARTS.	TICKETS.	PINTS	TICKETS.	QUARTS.	TICKETS.	DELIVERED.	RETURNED.
1																		
2																		
3																		

Form of Route Book.

The route book consists of loose leaves, upon which the names of customers are arranged alphabetically. The leaves are renewed each month, the old one being placed on file for future reference. The letters B. M. stand for buttermilk.

Ledger. As a rule all accounts are settled monthly. The ledger form shown below serves satisfactorily as a permanent monthly record.

On the debit side are recorded the sales and the total value of the tickets purchased. On the credit side are

recorded all the receipts for the same period. The *balance* represents the difference between the debits and credits.

Dr. John Smith Cr.

DATE 1908.	CASH.	TICKETS. MILK.	CREAM.	BUTTER-MILK.	BOTTLES.	DATE 1908	CASH.	TICKETS. MILK.	CREAM.	BUTTER-MILK.	BOTTLES.
JAN 1-31	8.00	30	10	10	50	JAN 1-31	6.00	25	10	8	46
						BAL. JAN 31	2.00	5	0	2	4
BAL. FEB. 1	2.00	5	0	2	4						
FEB. 1-29											

Form of Ledger.

Monthly Statement. At the end of each month a statement should be rendered to customers showing their indebtedness. A form like that herewith shown answers the purpose satisfactorily.

SPRINGDALE SANITARY DAIRY,
J. C. BOONE, Proprietor

REIDSVILLE, N. H., March 1 1908

Mr. John Smith

TO SPRINGDALE SANITARY DAIRY, DR.
J. C. BOONE, Proprietor

	Balance Feb. 1	2	50		
Feb. 1-28	40 quarts milk @ 8	3	20		
"	11 pints cream @ 20	2	20		
"	5 quarts buttermilk @ 5		25	8	15
"	By cash			6	00
	no. of unreturned bottles, 8			2	15

Monthly Statement.

Order Book for Supplies. For convenience as well as for permanent record, all orders should be made in duplicate in a book specially made for the purpose. The leaves in the order book are alternately marked "original" and "duplicate," the duplicate being made at the same time as the original by using carbon paper between the two. A suitable form of order blank is shown below.

Original Springdale Sanitary Dairy.
J. C. Boone, Prop.
Order No. ..... Reidville, N. H. .....190..
To .....
.....
Dear Sir: Please deliver by.....the following:
.....
.....
.....
.....
.....
Invoice and ship to
Springdale Sanitary Dairy,
J. C. Boone, Prop., Reidville, N. H.

CHAPTER XXI.

PASTEURIZATION OF MILK AND CREAM.

The process known as pasteurization derives its name from the eminent French scientist Pasteur. It consists in heating and cooling milk and cream in a manner which will destroy the bulk of bacteria in them, but which will leave their chemical and physical properties unchanged as far as possible.

Advantages of Pasteurization. The advantages to be derived from pasteurization vary with the conditions under which the milk is produced and the efficiency with which the work is conducted. If the milk comes from dairies where disease and uncleanliness prevail, pasteurization will prolong the keeping quality of the milk and also materially lessen the danger from disease germs. If, on the other hand, healthfulness and cleanliness receive the exacting attention which prevails on certified dairy farms, nothing can be gained by subjecting milk to the pasteurizating process.

Disadvantages of Pasteurization. The principal disadvantages are as follows: (1) the cost of pasteurizing apparatus; (2) the cost of pasteurizing; (3) the tendency to promote uncleanliness on the part of the producer; (4) the tendency to reduce the cream line on the milk; (5) lessening of the whipping property of the cream; and (6) the tendency to impart a "cooked" flavor to the milk and cream.

Methods of Pasteurization. Two general methods

are now in vogue: (1) the *discontinuous* method by which every particle of milk and cream is heated from ten to thirty minutes according as the temperature is high or low; (2) the *continuous* method by which milk and cream are permitted to pass in a constant stream through the pasteurizer and are subjected on an average less than one minute to the pasteurizing temperature.

In general the most efficient pasteurization is obtained with the discontinuous method.

Pasteurizing Temperatures. Obviously where milk is heated only a minute or less, a higher temperature must be employed than where it is heated for a much longer period of time. With the continuous method the temperature varies from 160° to 180° F. With the discontinuous method the temperature varies from 140° to 155° F. Exposing milk or cream to a temperature of 145° F. for twenty minutes results in very satisfactory pasteurization. The temperature and time of exposure should always be such as to insure the destruction of the tubercle bacillus, which is one of the most resistant of the disease bacteria most commonly found in milk.

Quick Cooling. In pasteurizing the heating must be quickly followed by thorough cooling. This is an extremely important part of the pasteurizing process. It is desirable that the temperature be reduced at once to 45° F. or below.

Viscogin. Thorough pasteurization reduces the viscosity or whipping property of cream. To restore the original viscosity a solution of sucrate of lime is added, which is known as viscogin. This solution is made by adding an excess of slaked lime to three parts of sugar dissolved in five parts of water. The mixture is al-

lowed to stand twenty-four hours, after which the clear liquid at the top is poured from the sediment and preserved in a stoppered bottle.

Add one part viscogin to about 150 parts of cream. Never add so much as to render the cream alkaline.

While viscogin is entirely harmless, it is nevertheless an adulterant and cream treated with it must be so labeled.

Inefficient Pasteurization. Milk that has been underheated is more dangerous than that which has not been heated at all. The reason for this is that inadequate heat in pasteurizing may destroy the lactic acid bacteria (which are easily killed) and by so doing actually better the conditions for the growth of the more resistant and obnoxious kinds. Lactic acid organisms are antagonistic to other classes of bacteria and are therefore a real safeguard to milk. This makes it plain that unless milk is pasteurized at a temperature which will destroy the pathogenic and non-acid bacteria as well as the acid bacteria, it is far better not to heat it at all.

Pasteurization should be condemned where its only object is to keep milk sweet. Its real object should be to destroy all actively growing bacteria and especially all disease-producing organisms such as the tubercle bacillus which is among the most resistant.

Pasteurizing in the Home. If milk must be pasteurized to render it safe, there is no better place to do this than in the home where it is to be consumed. The pasteurizing is very easily and satisfactorily accomplished by the use of a small double milk or rice boiler which can be procured for about one dollar from hardware dealers everywhere. It is essential to stir the milk while heating and to use a reliable thermometer.

CHAPTER XXII.

CERTIFIED MILK.

Definition. Certified milk is milk produced under conditions imposed by medical milk commissions, which usually employ a veterinarian, a bacteriologist and a chemist to look after the production of the milk. It must

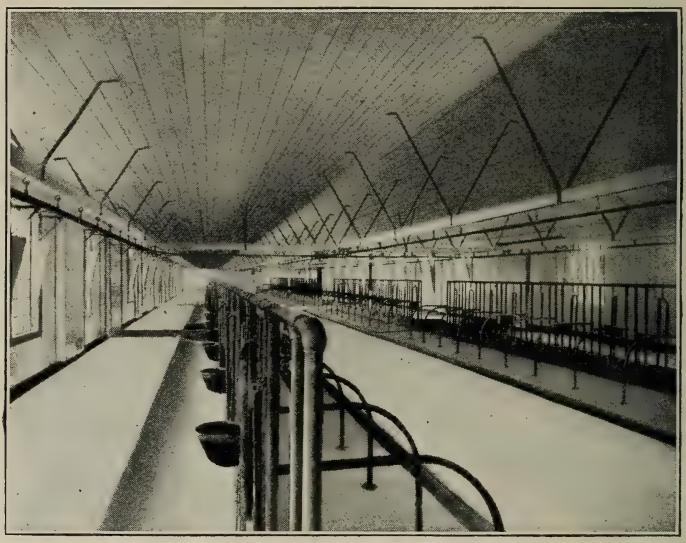


Fig. 60.—Sanitary Dairy Barn. (Da. Div., U. S. Dept. of A.)

be free from disease germs and preservatives, must have a known chemical composition, and must be so produced and handled as to insure a minimum number of bacteria.

If the producer has complied with all the requirements he is furnished a certificate by the commission, which permits him to use the "certified" label on his products.

The term "certified milk" is registered in the United States patent office and its use is legally permitted only on milk approved by medical milk commissions.

Uses. Certified milk is now largely used for infants and invalids. There is, however, also a rapidly increasing

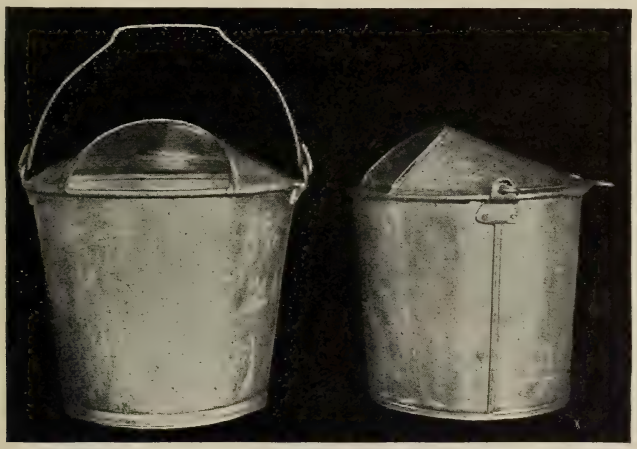


Fig. 61.—Truman Sanitary Milk Pail. (Storrs, Conn. Station.)

use made of this milk by the better informed people who realize the unsanitary condition of average market milk. Certified milk is the means of saving the lives of thousands of infants and its increasing use offers splendid opportunities for dairymen who are in a position to meet the requirements laid down by medical commissions.

Production and Handling. The general conditions called for in the production of "certified" milk are essentially the same as those stated in the chapter on "sanitary milk production."

The cows, milkers and premises are regularly inspected, and the milk is regularly subjected to chemical and bacteriological tests. The number of bacteria permitted by different commissions varies from 10,000 to 30,000 per cubic centimeter of milk; and the fat content ranges from about 3.5 to 4.5 per cent.

The milk bottles are sealed preferably with metallic caps bearing the date of bottling and the name of the commission, (see page 188). Delivery should be made within twenty-four hours after the milk is drawn and its temperature during this time should not exceed 45° F.

In the dairy house arrangements must be such as to reduce contamination to a minimum. A receiving can placed in an ante-room is used by the milkers to empty their pails, and from this the milk is conducted into the milk room. A sterilizer with doors at both ends is preferably placed between the milk room and the wash room, so as to enable the milkers to get their pails without entering the milk room and, at the same time, to allow the sterilized bottles to be removed without entering the wash room.

Profits. Obviously it costs more to produce certified than average market milk, but the additional cost is less, as a rule, than the increased price realized. Certified dairies that have failed to make money have almost invariably invested more money in buildings and equipment than was actually necessary. It has been shown that this class of milk may be successfully produced in quite ordinary buildings and with moderately cheap equipment. What is of greatest importance is extreme cleanliness, which is achieved mainly through intelligent care and management of every detail of the work from start to finish.

CHAPTER XXIII.

THE CARE OF MILK IN THE HOME.

No matter how good the condition of the milk when delivered, if carelessly handled in the home it will keep sweet but a very short time and the dairyman will get the blame. It is of vital interest to dairymen, therefore, to instruct their customers in the proper care of the milk in the home.

There is no doubt that a great deal of good milk is spoiled in the home of the consumer. This, as a rule, is the result of ignorance. Few consumers have a good knowledge of milk and, therefore, do not know how to care for it. If milk producers will bring the following suggestions to the attention of their customers, it may relieve them of much of the complaint they have hitherto been obliged to suffer:

INSTRUCTIONS TO CONSUMERS.

To keep milk and cream sweet and pure, they must be kept cold and clean. As soon as the milk is delivered, it should be put in a cool place—a clean refrigerator if possible. The vessels in which the milk and cream are kept must be sterile and covered. Vessels are not sterile unless they have been kept in boiling water for five minutes and then inverted upon a clean shelf without wiping.

On account of their great absorption properties milk and cream must be kept in covered vessels, especially when placed in the kitchen or cellar or possibly in the refrigerator with fruits and vegetables. Aside from absorbing odors when exposed in these places, they will also take up bacteria which will shorten their keeping quality.

At 45° F. milk may be kept perfectly sweet for twenty-four hours, while at a temperature of 70° it may sour in less than six hours. This emphasizes the importance of cold in preserving milk and cream.

Pour milk from one vessel to another as little as possible to avoid contamination. The best plan is to keep it in the original bottles.

Do not add new milk to old milk; neither add warm milk to cold.

The tops of the bottles should always be washed before removing any milk. They are more or less contaminated with dust during transportation and also become soiled from the hands.

Always clean the bottles before returning them.

Finally it is well to remember that the lowest-priced milk is usually also the poorest and dirtiest. Such milk in the end will prove the most expensive.

CHAPTER XXIV.

THE BOILER AND ITS MANAGEMENT.

A boiler is indispensible in a well equipped dairy. The steam which it provides is important, not only in securing hot water and in sterilizing, but also in furnishing power. A steam engine will be found useful in most dairies for pumping water, separating milk, churning and freezing cream, and by extending the shaft through one side of the building its usefulness may be extended to sawing wood, washing clothes, running the grindstone, etc.

For the smaller dairies the upright form of boiler will be found the most satisfactory. But for dairies having upwards of fifty cows, the horizontal form of fire-tube boiler should be used. The latter style is laid in brick. The grates are supported upon brickwork and heat and smoke pass along the underside of the boiler toward the rear and return through the fire-tubes. To prevent radiation of heat the brick work must be built up to cover the entire boiler. The fire box must be constructed of the best fire brick.

The various boiler accessories will be described in the following paragraphs:

Glass Gauge. This is a glass tube attached to the side of the boiler to indicate the height of the water in it. It is so attached that its lowest point is about two inches above the highest part of the fire line of the boiler, its entire length being usually about fifteen inches. The

cock at the bottom is used to blow out the sediment that is liable to block the opening between it and the boiler. When this occurs the gauge becomes a false indicator. Frequent blowing out is therefore necessary. The cock next to the blow-out admits the water from the boiler. The cock above this admits the steam. When the glass breaks shut off the water first, then the steam. Always have a few extra glasses on hand so that the broken one can be immediately replaced. Owing to its tendency to clog, the gauge can not always be relied upon, hence the use of water cocks placed next to the glass gauge.

Water Gauge Cocks. There are three of these used. The water level should be kept as near as possible to the middle cock. It should never go below the lower cock, nor above the upper. These cocks should be opened many times during the day, and so long as steam issues from the upper and water from the lower cock, the water level is all right.

Steam Gauge. This shows the number of pounds of steam pressure per square inch on the boiler by means of a pointer moving around a dial. Below the dial is a loop which contains water to prevent injury to the gauge from the hot steam. The steam gauge is liable to get out of order and will then fail to show the true pressure. Such a condition is indicated by the safety valve.

Safety Valve. This is placed on top of the steam chamber and permits the escape of steam when the steam pressure reaches the danger limit. It is an indispensable boiler attachment as without it the boiler would be a dangerous thing. There are two kinds of safety valves, the "pop" and "ball and lever" types. The former is considered the more desirable because it is not so easily

tampered with. Both can be set to blow off at different pressures.

Water Feed Apparatus. There are two ways of feeding water into a boiler, namely, with injectors and with pumps.

Injector. This important boiler accessory is attached to the side of the boiler. It utilizes the steam directly from the boiler for forcing water into it against a pressure as great as that which sends it forth. The principle which makes this possible may be stated as follows: Steam issuing from a boiler under 70 pounds pressure has a velocity of 1,700 feet per second. When steam with this high velocity strikes the combining tube it produces suction which in turn induces a flow of water. As soon as the water enters the combining tube it is given motion by the high velocity of the steam, which immediately condenses and moves with the water into the boiler at a comparatively low velocity. The energy, therefore, by which steam can force water into the boiler against its own pressure is the latent heat resulting from the condensation of the steam in the combining tube.

From this it must be evident that the efficiency of the injector is dependent upon the completeness with which the steam condenses. This is clearly proven by every day practical experience. When, for instance, the feed water is too hot, the steam pressure too high, or the steam is wet, the injector fails to work properly because the steam does not sufficiently condense when it strikes the feed water.

Starting the Injector. This is done by opening the supply water valve one or two turns, then the steam valve wide. If steam issues from the overflow admit a little more water; if water overflows admit less.

Care of Injector. An injector will become coated with sediment or scale the same as the boiler and must, therefore, be frequently cleaned. This is best done by immersing it in a solution of one part muriatic acid and ten parts water. Allow to remain in this solution until the scale becomes soft enough to permit washing out. A clean injector rarely causes trouble but if trouble does occur it may be due to : (1) low steam pressure; (2) too hot water; (3) leaks in pipes and injector; (4) clogging of water pipe; (5) wet steam; (6) poor working condition of check and overflow valves; (7) clogging of feed pipe where it enters the boiler.

The injector is commonly used to feed water into the boiler because it is cheap and simple, and occupies little space.

Pumps. There are two kinds; (1) those run with steam directly, and (2) those run by the engine. The latter is the more economical and handles hot water with less trouble. It has one disadvantage, however, and that is it does not work unless the engine is running. With good pumps, especially those run by the engine, good work may be expected when the feed water has been heated to 200° F. with the exhaust steam from the engine. With the injector such high temperatures are not permissible, hence the greater economy of the pump. The great saving of fuel by feeding water hot into the boiler is illustrated by experiments made by Jacobus which show that with a direct acting pump 12.1% fuel is saved by heating the feed water from 60° to 200° before pumping it into the boiler. With injectors the feed water used usually has a temperature of about 60° F.

Steam. Water is practically a non-conductor of heat. This means that it cannot conduct its heat to its neighbor-

ing particles. When, therefore, heat is applied to the bottom of a vessel containing water, the particles at the bottom do not communicate their heat to the particles next above them, but expand and rise, cool ones taking their places. This gives rise to convection currents which tend to equalize the temperature of the water in the vessel. When the water has reached a uniform temperature of 212° F. the particles begin to fly off at the surface in the form of vapor, and this we call *steam*. To generate steam in a boiler, then, it is necessary to impart to the water in it a considerable amount of heat, which is produced by burning fuel in the fire box.

FIRING OF BOILER.

The immense amount of heat stored in wood and coal is rendered effective in the boiler by burning (combustion). To understand how to fire a boiler intelligently one must first learn what the process of burning consists of.

Process of Burning. Anything will burn when the temperature has been raised high enough to cause the oxygen of the air to unite with it. Thus, in "striking" a match the temperature is raised high enough by the friction produced to cause the match to burn. The burning match will produce heat enough to ignite the kindling, which in turn, produces the necessary heat to ignite the wood or coal in the fire box of the boiler. Burning may, therefore, be defined as the union of the oxygen of the air with the fuel. In burning a pound of coal or wood a definite amount of air must be admitted to furnish the necessary oxygen for complete combustion. When oxygen is lacking part of the fuel passes out of the chimney un-

burned in the form of gases. If, on the other hand, too much air is admitted the excess simply passes through the chimney, absorbing heat as it passes through the boiler. The problem of firing becomes, therefore, a difficult one.

Burning Coal and Wood. When hard coal is burned the fire should be thin. A thickness of three to four inches on the grates gives very satisfactory results. For best results with soft coal a thickness of six to seven inches is recommended. Whenever fresh coal is added it should be placed near the front and the hot coals pushed back.

In case wood is burned the fire box should be kept well filled, care being necessary to keep every part of the grates well covered.

GENERAL POINTERS ON FIRING.

1. Boilers newly set should not be fired within two or three weeks after setting and then the firing should be very gradual for several days to allow the masonry to harden without cracking.

2. Never fire a boiler before determining the water level by trying the water gauge cocks. You can not entirely rely upon glass gauges, floats, and water alarms.

3. When starting the fire, open the upper water gauge cock and do not close it until steam begins to issue from it. This permits the escape of confined air.

4. Kindle the fire on a thin layer of coal to protect the grate bars.

5. Always examine the safety valve before starting a fire.

6. When starting the fire all drafts should be open.

7. The firing should be gradual until all parts of the boiler have been heated.

8. Never allow any part of the grate bars to become uncovered during firing.

9. Frequently clean the ash pit to prevent overheating of grates from the hot cinders underneath.

10. The coals upon the grates should not be larger than a man's fist.

11. Remember that firing up a boiler rapidly is apt to cause leaks.

12. Remember that too little water in the boiler causes leaks and explosions.

13. Remember that soot and ashes on heating surfaces always waste fuel.

14. When fire is drawn, close dampers and doors of furnace and ash pit.

15. Never open or close valves when the water is too low in the boiler, but immediately bank the fire with ashes or earth. Opening the safety valve at such a time will throw the water from the heated surfaces, resulting in overheating and possibly in explosions.

16. Use the poker as little as possible in firing.

17. Keep the grate bars free from "clinkers."

18. When the steam pressure goes too high, start the pump, open the doors of the furnace and close the ash pit.

19. A steady and even fire saves fuel.

GENERAL CARE OF BOILER.

1. Always close the steam and water valves of the glass gauge when you leave the building for half an hour or more.

2. Water gauges should frequenty be blown out and cleaned.

3. Keep the exterior of the boiler dry. Moisture will corrode and weaken it.

4. The boiler should be blown off under low pressure every two or three days.

5. A boiler that is not used for some time should be emptied and dried. If this cannot readily be done, fill it full of water to which a little soda has been added.

6. Frequently examine the safety valve to see that it is in good working order.

7. Do not empty boiler while brick work is very hot.

8. Never pump cold water into a hot boiler. Leaks and explosions may be the result.

9. Leaky gauges, cocks, valves, and flues should be repaired at once.

10. Do not fail to examine the pressure gauge frequently.

11. It is good policy to have two means of feeding a boiler. The pump or injector may get out of order and cause delay and danger.

12. Feed pumps and injectors need frequent cleaning to keep them in good working order.

13. Look out for air leaks. If air is admitted anywhere except through the grates serious waste may result. Such leaks are to be looked for in broken doors and poor brick work.

14. Flues should be cleaned often, especially if soft coal is burned. This will prevent overheating of metal and at the same time save fuel.

15. Do not allow filth to accumulate around the boiler or boiler room.

16. Keep all the bright work about the boiler "shiny."

17. Do not fail to empty the boiler every week or two and refill with fresh water.

18. Have your steam gauge tested at least twice a year.

BOILER INCRUSTATION.

In all boilers after a period of use, there is deposited upon the parts below the water level a scale or sediment known as boiler incrustation.

Cause of Scale. The formation of scale is due to the impurities contained in the feed water. When impure water is fed into the boiler the impurity first manifests itself in the form of scum on top of the boiling water. The heavier particles of the scum slowly unite and sink to the bottom where they first appear as mud. By continued exposure to high temperature, this mud gradually forms into a hard impervious scale which usually consists largely of lime.

Objection to Scale. 1. The excessive formation of boiler scale is the immediate cause of most boiler explosions. The scale acts as a non-conductor of heat, so that in cases where the capacity of the boiler is severely taxed, the metal becomes overheated, thus materially weakening it. The scale is, therefore, not only dangerous, but by overheating the metal, also materially shortens the life of the boiler. 2. Another most serious objection to scale is its wastefulness of fuel. This becomes evident when we note that the heat before reaching the water must first be conducted through a non-conducting layer of incrustation.

Prevention of Scale. Since nearly all water used for boilers is more or less impure, it is evident that to prevent scale, boilers must receive frequent cleaning. How often

this needs to be done is, of course, dependent upon the amount and character of the impurity in the water. Boilers are kept clean in three different ways, (1) by blowing off at low pressure, (2) by cleaning through manhole, and (3) by using boiler compounds.

(1). By blowing the boiler off at low pressure most of the mud will be blown out. But care must be taken that the pressure is not above ten pounds and that there is no more fire in the fire box, otherwise the mud, instead of flowing out with the water, will bake on and form scale.

(2). A good way of removing mud is to allow the boiler to cool off and then run a rubber hose through the manhole. By working the hose and forcing water through it the sediment can be removed.

(3) Boiler compounds are used to keep boilers free from scale. The kind of compound to be used is determined by the character of the impurities of the water. Most dairies use well water for the boiler and the chief impurity in this is lime. The best compound for water of this kind is soda. Well water contains the lime in widely different proportions. In order, therefore, to ascertain the proportion of soda to feed water the following method is recommended by Hawkins:

"1. Add one sixteenth part of an ounce of soda to a gallon of the feed water and boil it. 2. When the sediment thrown down by the boiling has settled to the bottom of the kettle, pour the clear water off and add one-half drachm of soda to this. Now, if the water remains clear, the soda which was put in has removed the lime. But if it becomes muddy, the second addition of soda is necessary." In this way the amount of soda to be added to the feed water can be calculated with sufficient accuracy.

Tan bark is very efficient in removing boiler scale but may injure the iron.

Kerosene answers the same purpose but renders the steam unfit for use in the dairy.

When the water is salt or acid, a piece of metallic zinc occasionally placed in the boiler will prevent corrosion. Water of this kind can usually be told by its corrosive effect on copper and brass. Acid water can also be detected with blue litmus paper, which it turns red.

WET AND DRY STEAM.

Wet Steam. This is steam holding in suspension extremely small particles of water which are thrown off from the water surface while steam is generating. The following are the causes of wet steam:

1. Impure water in the boiler.
2. Too much water in the boiler.
3. Too little evaporating surface for the amount of steam used. This is one of the chief objections to upright and too small boilers.
4. Violent agitation of the water in the boiler caused by too rapid a generation of steam.

Wet steam causes "priming" and is wasteful of heat.

Dry Steam. This is saturated steam holding no water mechanically in suspension. High steam pressure and a large steam space above the water level are conducive to dry steam.

CHAPTER XXV.

WATER AND ICE SUPPLY.

WATER SUPPLY

Importance of Pure Water. A great deal of disease in farm homes is directly traceable to infected water. Typhoid fever especially is so frequently caused by polluted well water that physicians at once look to this as the probable cause wherever this disease is found to exist.

Where wells infected with disease germs happen to exist on dairy farms that supply milk to neighboring cities, disease is not limited to the dairyman's own family, but may be spread along the entire milk route. Many typhoid fever epidemics have been positively traced to milk which has become infected through water containing the disease germs. Nowhere is pure water so important, therefore, as upon dairy farms.

The disease germs usually find their way into the milk through milk vessels which have been washed with infected water. The use of such water for washing cows' udders previous to milking may also be the means of infecting the milk supply.

Location of Well. The most satisfactory location for the well is at the dairy house where the coldest water is required and where it will be most convenient. Here the water for both the dairy, the home, and the stock can be pumped with the dairy engine. Further, the well, like

the dairy house, should stand on slightly elevated ground so as to insure drainage away from it.

Construction of Well. In a properly constructed well, no water should enter it except near the bottom. This compels the water to pass through a thickness of earth sufficient to purify it where the wells are of a reasonable depth.

Where there is no rock or hard clay and where the

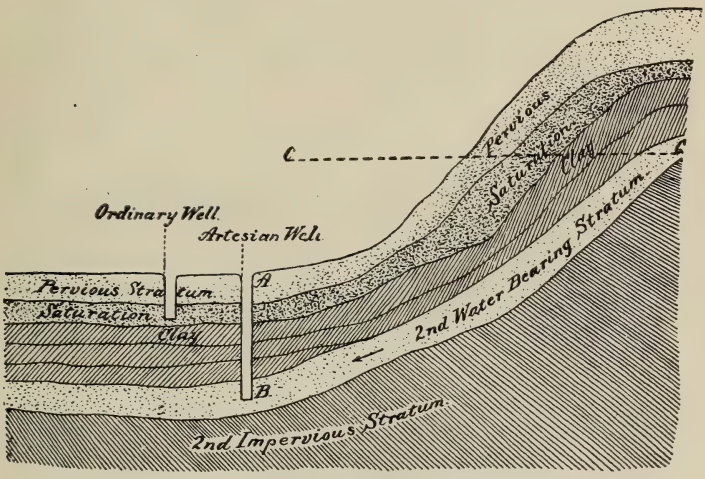


Fig. 62.—Soil Strata. (From Harrington's "Practical Hygiene.")

water can be had at a reasonable depth, the driven well, commonly known as the Abyssinian tube well, is the cheapest and one of the safest. This well is made by driving into the ground a water-tight iron tube, the lower end of which is pointed and perforated.

In case rocks and hard clay must be penetrated, or great depth must be reached to secure water, the bored or drilled well, piped from top to bottom with water-tight iron pipes, will be found most satisfactory.

Water from the upper pervious stratum should be avoided wherever possible, even with wells of the kind just described. Especially is this necessary where the wells are shallow. The purest water is obtained by sinking the well through an impervious stratum, like that shown in Fig. 62.

The most dangerous well is the common dug well with pervious walls and so located as to permit seepage into it from outhouses, barnyards and cesspools. Wells of this type are altogether too common on dairy farms.

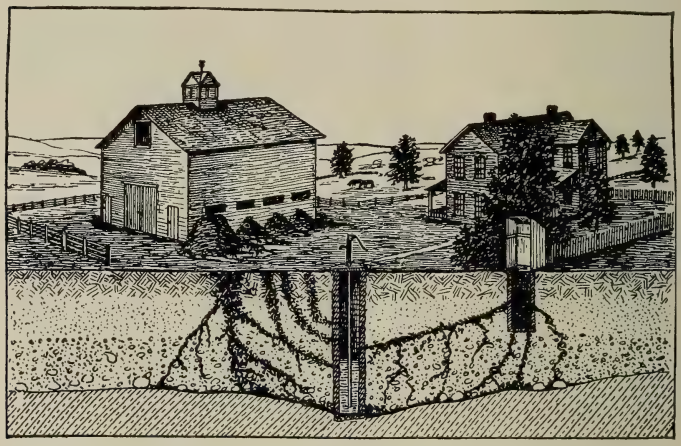


Fig. 63.—Sources of Well Water Contamination. (From Bul. 143 Kan. Exp. Sta.)

All wells, whatever their construction, must be provided with water-tight metallic or concrete covers to prevent the entrance of impurities into the shaft.

ICE SUPPLY.

Necessity of Ice. Where there is no equipment for

mechanical refrigeration, ice is indispensible in furnishing the best quality of milk and cream. A low enough temperature cannot be secured with water alone, neither can the cooling be accomplished as quickly as is desirable for best results. Furthermore, a satisfactory cold storage cannot be had without the use of ice.

Cooling Power of Ice. A great deal of cooling can be done with a comparatively small amount of ice. This is due to the latent or "hidden" cold in ice. Thus to convert one pound of ice at 32° F. into water at the same temperature requires 142 units of heat, or, in other words, enough cold is given out to reduce the temperature of 142 pounds of water one degree Fahr.

Construction of Ice House. To keep ice satisfactorily three things are necessary, (1) good drainage at the bottom, (2) good insulation, and (3) abundant ventilation at the top.

Good drainage and insulation at the bottom can be secured by laying an eight-inch foundation of stones and gravel and on top of this six inches of cinders, the whole being underlaid with drain tile. One foot of sawdust should be packed upon the cinders and the ice laid directly upon the sawdust.

Satisfactory walls are secured by using matched boards on the outside of the studs and common rough boards on the inside, leaving the space between the studs empty. The ice should be separated from the walls by one foot of sawdust.

Where no solid foundation walls are provided, earth must be banked around the ice house to prevent the entrance of air along the base.

The space between the sawdust covering on top of the ice and the roof should be left clear. Openings in the

gable ends as well as one or two ventilating shafts projecting through the roof should be provided to insure a free circulation of air under the roof. This will not only remove the hot air which naturally gathers beneath the roof, but will aid in drying the sawdust.

The ice must be packed solidly, using no sawdust except at the sides and bottom of the ice house and on top of the ice when the filling is completed. At least one foot of sawdust must be packed on top of the ice.

Size of Ice House. The size of the ice house will depend, of course, upon the amount of ice to be used. For a herd of 25 cows, in the North, an ice house 10 feet square by 14 feet high will usually answer. These dimensions provide storage for 22 tons of ice, allowing one-foot space all around the ice for sawdust. In the South about 50% more ice is required than in the North.

In calculating the amount of storage space needed for ice, it is necessary to know that one cubic foot of ice at 32° F. weighs 57.5 pounds.

As a matter of convenience in filling and emptying the ice house, doors should be provided in sections from the sill to the gable at one end of the building.

General Uses of Ice. Aside from the use of ice in cooling milk and cream, it can be employed to good advantage in several other ways. Its value in the household, in preserving meats, vegetables, and fruits cannot be overestimated. And what is so refreshing as cold drinks and frozen desserts during the summer months! Ice is also frequently necessary in case of sickness.

Cost of Making Ice. Where ice can be obtained within a reasonable distance, the cost of cutting, hauling, and packing should not exceed $1.50 per ton.

Source of Ice. Always select the cleanest ice available.

Where the source of ice is at too great a distance from the dairy, an artificial pond should be made upon ground with a reasonably impervious subsoil and with a natural concave formation. If such a piece of ground is flooded with water during the coldest weather, an ample supply of ice will be available in a very short time.

CHAPTER XXVI.

SEWAGE DISPOSAL FROM DAIRY AND DWELLING.

To secure a high degree of sanitation in and about the dairy house it is necessary to see that proper disposal is made of the sewage from both the dairy and the dwelling. Where the latter is situated close to the dairy house its surroundings may do fully as much harm as those of the dairy itself.

With open privies and the careless dumping of kitchen slops near the dwelling, we have a double means of endangering the dairy. If the ground near the dwelling and privy slopes in the direction of the water supply, the latter is likely to become contaminated through seepage in the manner indicated in Fig. 63. In addition to this there is the danger of flies carrying various kinds of bacteria from these places to the dairy house. Flies not only carry the obnoxious, putrefactive species, but too often also the deadly pathogenic kinds, such as cause typhoid fever, to say nothing of the offensive excrementitious matter conveyed in this manner.

Obviously the accumulation of sewage about the dairy house is attended by practically the same danger as that arising from the unsanitary surroundings of the dwelling. Moreover there is certain to be trouble also from bad odors.

SEPTIC TANK.

The best means of taking care of the sewage from

both the dairy and the dwelling is to run it into a septic tank (see Fig. 64, designed by the author) and from this into a net-work of tile laid underground where it will irrigate and fertilize the soil.

Object of Septic Tank. The main purpose of the tank, as its name indicates, is to thoroughly decompose all organic matter entering it. This is accomplished by numerous species of bacteria, and the tank may be properly designated as a germ incubator. Where the

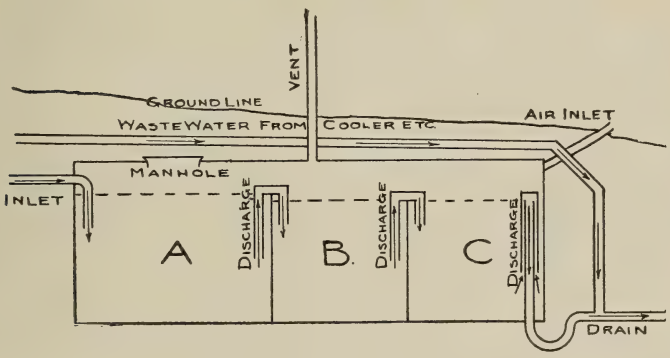


Fig. 64.—Septic Tank.

sewage is emptied into underground tile, the tank also serves as a storage, discharging its contents intermittently. This is necessary to force the liquid to all points of the system and to allow time for each discharge to soak away before the appearance of the next.

Construction of Tank. The general plan of construction is illustrated in Figs. 64 and 65. The tank is located in the ground with the top within a foot or two of the surface. For durability it is preferably constructed of brick, stone or concrete. The tank is so constructed as to

retain all sediment and floating material, since the discharges permit the withdrawal of the liquid from near the middle of the tank only. This is one of the main features of the tank. All inorganic matter entering the tank will gradually settle and, of course, remain in it. Some of the organic matter tends to settle during the first 24 hours, after which it comes to the surface to be gradually wasted away by the action of bacteria. This wasting away is naturally very slow, and since the slowly gathering organic matter nearly all remains in the first section of the tank, this must be large enough to provide for a considerable accumulation of it.

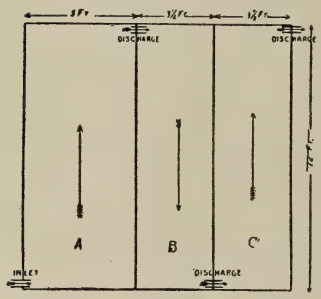


Fig. 65.—Cross Section of Septic Tank.

The tank should be built air tight, except in two places. At the right is an air inlet, consisting of a goose-neck pipe, which renders the vent at the top more effective. This vent consists of a long shaft extending beyond the top of the dairy, thus carrying off the foul gases caused by the decomposition of the material within. One-inch gas pipe, properly fastened, will serve as a satisfactory vent.

In order to afford communication of sections A and C with the vent, the two partitions should not be built quite as high as the tank. There should be at least one inch space between the top of the partitions and the cover.

A 1½-inch gas pipe should be laid over the tank through which the water from the cooler and vats may be discharged directly into the drain. This water

requires no purification and, if conducted through the tank, would necessitate one of too large dimensions. Moreover, the large amount of cold water needed for cooling milk and cream would cool the contents of the tank too much for a rapid decomposition of the material within.

Size of Tank. This must necessarily depend upon the amount of sewage run into it. In general it should have capacity sufficient to hold all of one day's waste in the smallest section (C). It will be noticed from the cut that section A is considerably larger than either of the other two. The reason for this is that nearly all of the inorganic matter remains in the bottom of this part of the tank, while the organic matter, as already stated, gradually accumulates at the surface in this section, in spite of constant decomposition. Where the tank receives the sewage from both the dairy and the dwelling, a tank 12 feet square by 4½ feet deep will be large enough, provided the water used for cooling is not run into it. It is well to remember, however, that the larger the tank used the better the results that may be expected from it.

Flow of Sewage Through Tank. Four-inch tile, carefully laid, may be used to conduct the sewage from the dairy to the tank. A trap is placed near the dairy to shut off the odors coming from the drain. At the point at which the sewage enters the tank it is desirable to attach an elbow with an arm sufficiently long to keep the lower end always in the sewage. This prevents undue mixing of the incoming sewage with that already in the tank, a matter of importance in the successful operation of the tank.

When the sewage in section A has reached the dotted line, it begins to discharge into section B through three-

inch gas pipe as shown in Fig. 64. The liquid is withdrawn from a point near the middle of the tank as indicated by the discharge pipes. The eight-inch space above the discharge permits the accumulation of organic matter. The discharge from B into C, is the same as that from A into B; but the discharge pipes are of necessity lower by an amount indicated by the dotted lines. Compartment C discharges intermittently by means of an automatic syphon.

The sewage becomes gradually purified in its passage through the tank, and as it flows from the last section it is nearly as clear as water, but has a slightly sour odor, which it seems to retain and which is in no way objectionable. The purified sewage has been kept for weeks with no sign of the development of putrefactive odors.

The discharges should be arranged as shown in Fig. 65. This arrangement will cause the least mixing of old and new sewage. There is no discharge from A into B until the second day's sewage flows into A. Similarly there is no discharge from B into C until the second discharge into B, etc. The sewage, therefore, requires from three to four days in its passage through the tank.

Cost of Septic Tank. A double partition tank, 12 feet square and 4½ feet deep, constructed of concrete consisting of one part cement, two parts sand and four parts gravel, will cost approximately $50.00 when the walls are five inches thick.

SEWAGE DISPOSAL FROM DWELLING.

The open privy and the cesspool of kitchen slops are objectionable not only in so far as they affect the dairy house, but also in that they constitute a source of danger to the members of the family in ways entirely disconnected with the milk supply. With the dairy house

already equipped with power to pump and elevate water, there is apparently no reason why the dwelling should not be equipped with a water closet. And with a water closet in the house there would be practically no expense connected with the disposal of the kitchen waste, since this would be discharged directly into the soil pipe connected with the closet. What a convenience such an equipment would afford to the housewife and members of the family!

If the dwelling and dairy house are reasonably close together, one septic tank will answer for both. In such a case the tank is located between the two buildings. Where a great distance separates the buildings, a tank is provided for each and the outlets are brought together as near the tank as possible to save extra expense of tile.

SUBSURFACE IRRIGATION.

While the septic tank sufficiently decomposes the organic matter to leave the sewage from the tank without offensive odors, it is best to run the discharge into a system of underground tile where it will serve as a fertilizer and as an irrigating agent. The tile should be laid below the frost line. In loose soils one foot of tile per gallon of sewage will answer. Clayey soils require two to three times this amount.

Three-inch agricultural drain tile are best adapted for drainage work of this kind, the tile being laid with open joints and with a slope of three or four inches per hundred feet.

It is important that this subsurface irrigating system be located where there is no seepage into the water supply. In places where there is no danger from frost it is best to lay the tile only about one and one-half feet below the surface.

APPENDIX.

Relationship of Fat and Solids-not-Fat. In normal milk a fairly definite relationship exists between the fat and the solids-not-fat. That is, milk rich in fat is likewise rich in solids-not-fat. This is an important point for the consumer to bear in mind, because when he buys milk rich in fat he gets milk which is also rich in the more important food constituents, namely, the proteids.

Composition of Cream. Cream contains all the constituents found in milk, though not in the same proportion. The fat may vary from 8% to 68%. As the cream grows richer in fat it becomes poorer in solids not fat. This is illustrated in the following figures by Richmond:

Total solids.	Solids not fat.	Fat.
Per cent.	Per cent.	Per cent.
32.50	6.83	25.67
37.59	6.14	31.45
50.92	5.02	45.90
55.05	4.65	50.40
57.99	4.17	53.82
68.18	3.30	64.88

The same authority also reports the following detailed analysis of a thick cream:

	Per cent.
Water	39.37
Fat	56.09
Sugar	2.29
Proteids	1.57
Ash	.38

Composition of Buttermilk. According to Vieth, buttermilk from ripened cream has the following composition:

	Per cent.
Water	90.39
Fat	.50
Milk sugar	4.06
Lactic acid	.80
Proteids	3.60
Ash	.75

Dairy buttermilk should not average above .2% fat.

Composition of Skim-milk. Richmond has found the following average composition of separator skim-milk:

	Per cent.
Water	90.50
Fat	.10
Milk sugar	4.95
Casein	3.15
Albumen	.42
Ash	.78

COMPARISON OF CENTIGRADE AND FAHRENHEIT THERMOMETER SCALES.

Thermometer.	F.	C.
Boiling point (water)	212	100
Freezing point (water)	32	0
Difference between boiling and freezing point	180	100

From the above it will be seen that one degree Centigrade is equivalent to 9-5 degrees Fahrenheit. Hence the following rules:

1. To change C. into F. reading, multiply by 9-5 and add 32.

Example: $50°C = (50 \times \frac{9}{5}) + 32 = 122°F.$

2. To change F. into C. reading, subtract 32 and multiply by 5-9.

Example: $182°F = (182 - 32) \times \frac{5}{9} = 83\frac{1}{3}°C.$

METRIC SYSTEM OF WEIGHTS AND MEASURES.

This system was devised by the French people and has very extensive application wherever accuracy in weights and measures is desired. Some of its equivalents in ordinary weights and measures are given in the following table:

Ordinary weights and measures.	Equivalents in metric system.
1 ounce (av.)	28.35 grams.
1 quart	0.9464 liter.
1 gallon	3.7854 liters.
1 fluid ounce	29.57 cubic centimeters (c.c.)
1 pound (av.)	0.4536 kilogram.
1 grain	64.8 milligrams.
1 inch	2.54 centimeters.
1 foot	0.3048 meter.

LINING UP SHAFTING.

Fasten a heavily chalked string along the ceiling parallel to the direction the shafting is to take. Snap the string, and a white mark will indicate the position of the shafting in a plane parallel to the floor. This plane is indicated by the line ab in Fig. 66. Next determine the position of the shafting in a plane at right angles to the

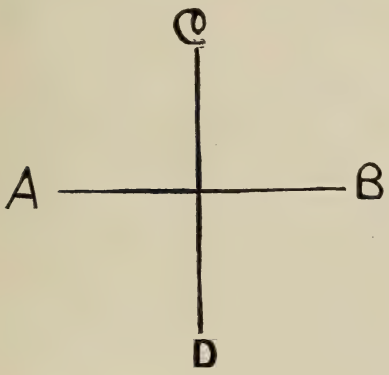


Fig. 66.—Intersecting Planes.

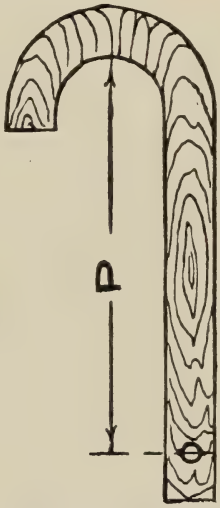


Fig. 67.—An Aid to Lining up Shafting.

floor, indicated by the line cd. This is done as follows: Loosely fasten the hangers along the white chalk line and properly fasten the shafting. Now hang on the shafting, at intervals of three feet, pieces of board like that shown in Fig. 67. The upper end is rounded to fit over the shaft, while the lower end is perforated as indicated in the Fig. These pieces of board must be carefully cut

so that the distance P is the same in all. If the holes at the lower ends are all in line the shafting is properly lined up. If not, the shaft needs readjusting.

CALCULATING SIZE AND SPEED OF PULLEYS.

The first thing to remember in determining the required size and speed of pulleys is the following rule: *The speed varies inversely with the diameter of the pulley.* Thus with the same speed of the engine, the speed of the main shaft becomes less as the diameter of the pulley on that shaft is increased.

We usually speak of two kinds of pulleys: the *drive* pulley and the *driven* pulley. Where the engine drives the main shaft the pulley on the engine is called the drive pulley and that on the main shaft the driven pulley. When we refer to the main shaft driving the separator, then the pulley on the main shaft becomes the driver and that on the separator the driven pulley.

In dairies there are two problems that present themselves with respect to pulleys: one is to find the speed of the pulley when the diameter is given; the other is to find the diameter when the speed is given.

1. To find the speed of a driven pulley: Multiply the diameter of the driver by its speed and divide the product by the diameter of the driven pulley.

Example: Diameter of engine pulley, 20 inches; speed of engine 200 revolutions per minute; diameter of driven pulley, 25 inches.

$20 \times 200 \div 25 = 160 =$ No. rev. per min. of driven pulley.

2. To find the diameter of driven pulley: Multiply the

diameter of driver by its speed and divide the product by the required speed of driven pulley.

Example: Diameter of engine pulley, 20 inches; speed of engine, 200 revolutions per minute; speed of driven pulley, 200 revolutions per minute.

$$20 \times 200 \div 200 = 20 = \text{diameter of driven pulley.}$$

CARE AND MANAGEMENT OF ENGINE.

1. It is essential to have all parts of the engine well oiled, using nothing but the best oil.

2. Keep the engine clean. The shiny parts should be brightened at least once a day.

3. Keep the engine well "keyed up." At both ends of the connecting rod are keys, the purpose of which is to keep the brass boxes tight enough to prevent undue play. The "keying" consists in loosening the burrs next to the key and then tapping the latter lightly until the unnecessary play is taken up. Care must be taken, however, not to get the brasses too tight or a hot box will be the result. "Pounding" is usually caused by not having the keys properly set. It is also caused by wet steam and water in the cylinder.

4. Keep stuffing boxes carefully packed to prevent leakage of steam. The packing should be treated with graphite or good cylinder oil and packed firmly around the rod, but it must not be too tight, otherwise power is lost in friction. If the rod has become scored or rusty, smooth it with emery cloth before packing.

5. The packing rings in the piston should be kept in good repair. The clicking noise sometimes heard in cylinders is due either to the packing ring wiping over

the edge of the counter bore or to its being too narrow for the groove in which it is placed. A ring is needed that fits this groove properly. If the packing ring is too small for the cylinder bore it should be set out by peneing or by tightening the setting out bolts.

6. When gumminess is noticeable in any of the bearings, remove same with benzine and use a purer oil.

7. When the engine "races" look for the trouble in the governor.

8. Thoroughly drain cylinder when not in use. This *must* be done in the winter to prevent freezing.

Bottle Sealed with Metallic Cap.

Metallic Milk Bottle Cap.

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